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TOPEX Radar Altimeter Engineering Assessment Report Update - Launch to January 1, 1997

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About the Series

The TOPEX Radar Altimeter Technical Memorandum Series is a collection of performance assessment documents produced by the NASA Goddard Space Flight Wallops Flight Facility over a period starting before the TOPEX launch in 1992 and continuing over greater than 10 year TOPEX lifetime. Because of the mission's success over this long period and because the data are being used internationally to redefine many aspects of ocean knowledge, it is important to make a permanent record of the TOPEX radar altimeter performance assessments which were originally provided to the TOPEX project in a series of internal reports over the life of the mission. The original reports are being printed in this series without change in order to make the information more publicly available as the original investigators become less available to explain the altimeter operation and details of the various data anomalies that have been resolved.

Foreword

The Engineering Assessment of the TOPEX Radar Altimeter is performed on a continuing basis by the TOPEX Altimeter Team at NASA/GSFC Wallops Flight Facility. The Assessment Team members are:

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For the latest updates on the performance of the TOPEX Radar Altimeter, and for accessing many of our reports, readers are encouraged to contact our WFF/TOPEX Home Page at http://osb3.wff.nasa.gov/topex/.

For additional information on this topic, please contact the Team Leader, David W. Hancock III. He may be reached at 757-824-1238 (Voice), 757-824-1036 (FAX), or by e-mail at hancock@osb.wff.nasa.gov.

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Section 1

Introduction

1.1 Identification of Document

The initial TOPEX Mission Radar Altimeter Engineering Assessment Report, in February 1994, presented performance results for the NASA Radar Altimeter on the TOPEX/POSEIDON spacecraft, from its launch in August 1992 to February 1994. There have been supplemental Engineering Assessment Reports, issued in March 1995 and again in May 1996, which updated the performance results through the end of calendar years 1994 and 1995, respectively. This supplement updates the altimeter performance to the end of calendar year 1996, and describes significant events that occurred during 1996.

As the performance data base has expanded, and as analysis tools and techniques continue to evolve, the longer-term trends of the altimeter data have become more apparent. The updated findings are presented here.

Section 2

On-Orbit Instrument Performance

From the time of initial turn-on after launch to the beginning of calendar year 1997, the NASA Radar Altimeter has been in TRACK mode for a total of approximately 33,900 hours. The altimeter has been in IDLE mode for an additional 3,900 hours since launch, generally due to the French Altimeter being turned-on. The altimeter has been in OFF mode for a total of 394 hours, due primarily to a 230-hour spacecraft-level Safehold which began on November 26, 1995, and to a 68-hour spacecraft-level Safehold which began on January 20, 1996.

Altimeter Side A continues to function well; Side B has not been turned-on since before launch. The Project, at this time, does not plan to turn-on Side B unless there is a failure of Side A. WFF has requested brief turn-ons of Side B, to enable a cross-calibration between the two Sides. The Side A C-Band frequency has remained at 320 MHz since launch, except for a very brief period shortly after launch when the bandwidth was switched to 100 MHz, to affirm its operability.

The parameter file C35028SL, described in Table 5.8.4 of the February 1994 Engineering Assessment Report, was in use until day 40 of 1995. On that day, at 1920 UTC, a new parameter set, C3502840, was implemented. The only difference between the two parameter sets is that the initial AGC acquisition value prior to the first cal mode is 40 dB instead of the previous 60 dB. The rationale for this change is discussed in Section 2.2.8 (page 27) of the March 1995 Engineering Assessment supplement. Parameter file C3502840 continues to be used.

The succeeding sub-sections discuss:

- launch-to-date internal calibration results
- launch-to-date cycle summary results
- launch-to-date key events

2.1 Launch-to-Date Internal Calibrations

Internal altimeter calibrations are scheduled twice-per-day, over land areas, at approximately 0000 UTC and 1200 UTC. Internal calibrations are also performed whenever the NASA altimeter is commanded from TRACK to IDLE for a period of tracking by the French altimeter, or from IDLE back to TRACK when tracking resumes for the NASA altimeter. The WFF database presently contains approximately 3000 internal calibration sets. The calibrations prior to and after the French altimeter operations are not constrained to land areas, and usually occur over open-ocean.

2.1.1 Range Calibrations

Our processing of the calibration mode data was modified in 1994, to remove the effect of the 7.3 mm quantization; the revised method is discussed in Section 2.1.1

(page 2) of the March 1995 supplement. All the calibration data since launch have been reprocessed using the revised method. The change in Ku-Band range, from day 239 of 1992 to the beginning of 1997, is plotted in Figure 2-1 "Ku-Band Range CAL-1 Results" on page 2-3. CAL-1 steps 4 through 7 are shown in the Figure. Step 5 best represents typical AGC levels for normal ocean fine-track operation, and has been used for the range trend analysis presented in Section 3.1.

The delta range shown in Figure 2-1 (and in the succeeding calibration plots) is calculated based on the measurement minus a reference. This calibration range plot suggests that the Ku-Band delta range rate changed from a generally negative slope to a positive slope shortly after the beginning of 1996. In the figure, the year 1996 begins on elapsed day 1222.

The change in C-Band calibration range is depicted in Figure 2-2 "C-Band Range CAL-1 Results" on page 2-4. This plot indicates that, early in the mission, the C-Band range was negatively changing at the rate of several millimeters per year. Beginning in the latter part of 1994 and continuing through 1995, the C-Band range generally stabilized, although there was more frequent toggling of the 7.3 mm quantization step. Shortly after the beginning of 1996, and continuing throughout the remainder of the year, the range change has had a positive slope.

Range calibrations and their correction values are discussed in more detail in Section 3.1.

2.1.2 AGC Calibrations

2.1.2.1 CAL-1 and CAL-2

The change in Ku-Band AGC since launch is shown in Figure 2-3 "Ku-Band AGC CAL-1 and CAL-2 Results" on page 2-5. CAL-1 steps 4 through 6, plus CAL-2, are depicted in the Figure. As for the earlier range calibration, Step 5 of the CAL-1 AGC steps is considered to be the most typical for normal ocean operations. From launch to the end of 1995, the Ku-Band CAL-1 AGC had been decreasing at a rate approximating 0.3 dB per year. This past year, there was an accelerated linear AGC decrease of about 0.5 dB. Since launch, there has been an approximate 1.5 dB total decrease in CAL-1 AGC. The Ku-Band CAL-2 shows a decrease of about 0.1 dB during 1996, and a total decrease since launch of about 0.6 dB.

The change in C-Band AGC since launch is shown in Figure 2-4 "C-Band AGC CAL-1 and CAL-2 Results" on page 2-6. Similar to the Ku-Band, the C-Band AGC exhibits an accelerated rate of decrease during 1996. Prior to 1996, the total decrease since launch was about 0.7 dB; last year alone, there was a linear decrease of an additional 0.7 dB. The C-Band CAL-2 change is also similar to the Ku-Band in there was an approximate 0.1dB decrease during the year.

These AGC decreases are believed to be the result of normal component aging. A more thorough analysis of the AGC calibrations is presented in Section 3.2.

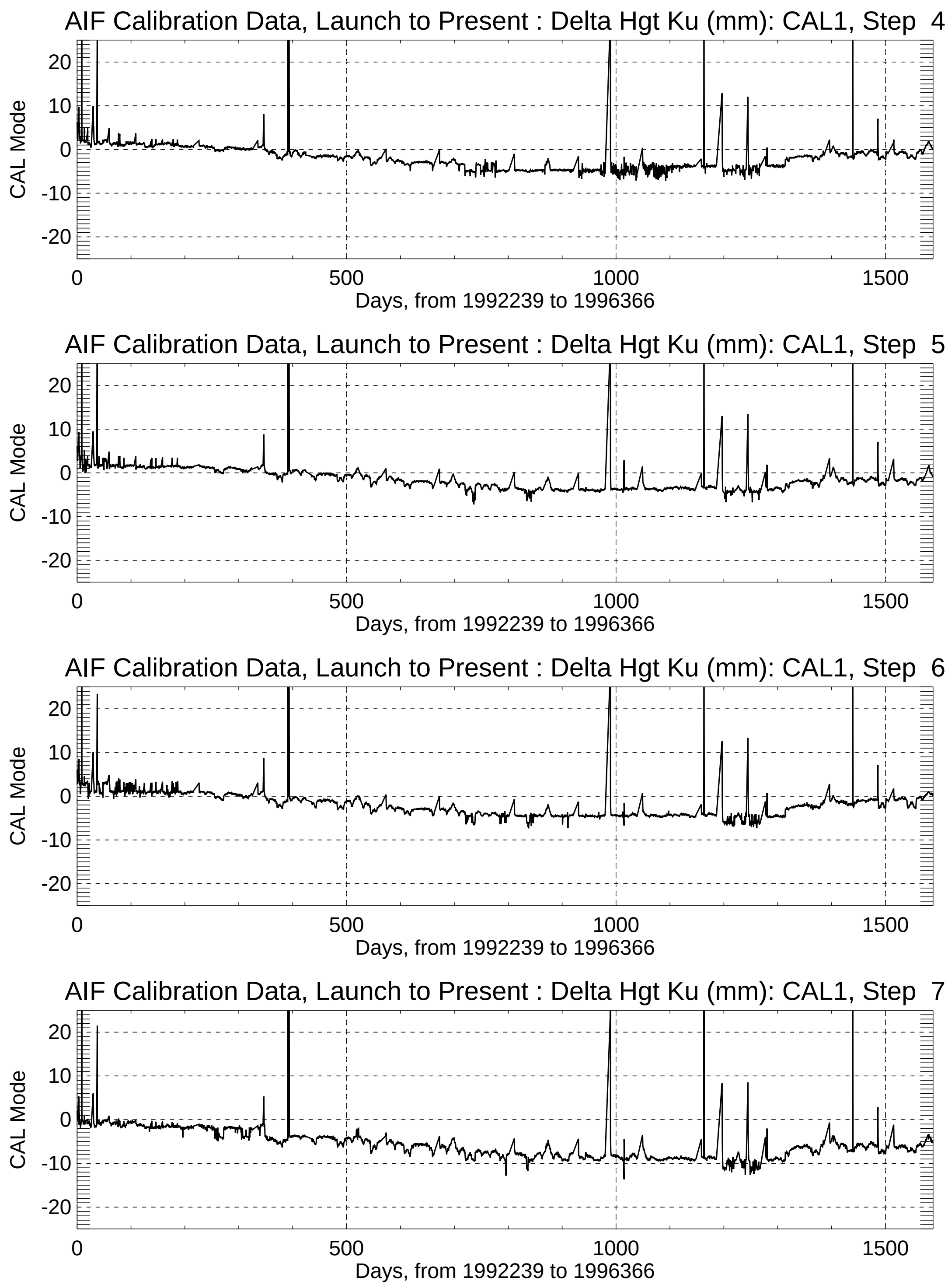


Figure 2-1 Ku-Band Range CAL-1 Results

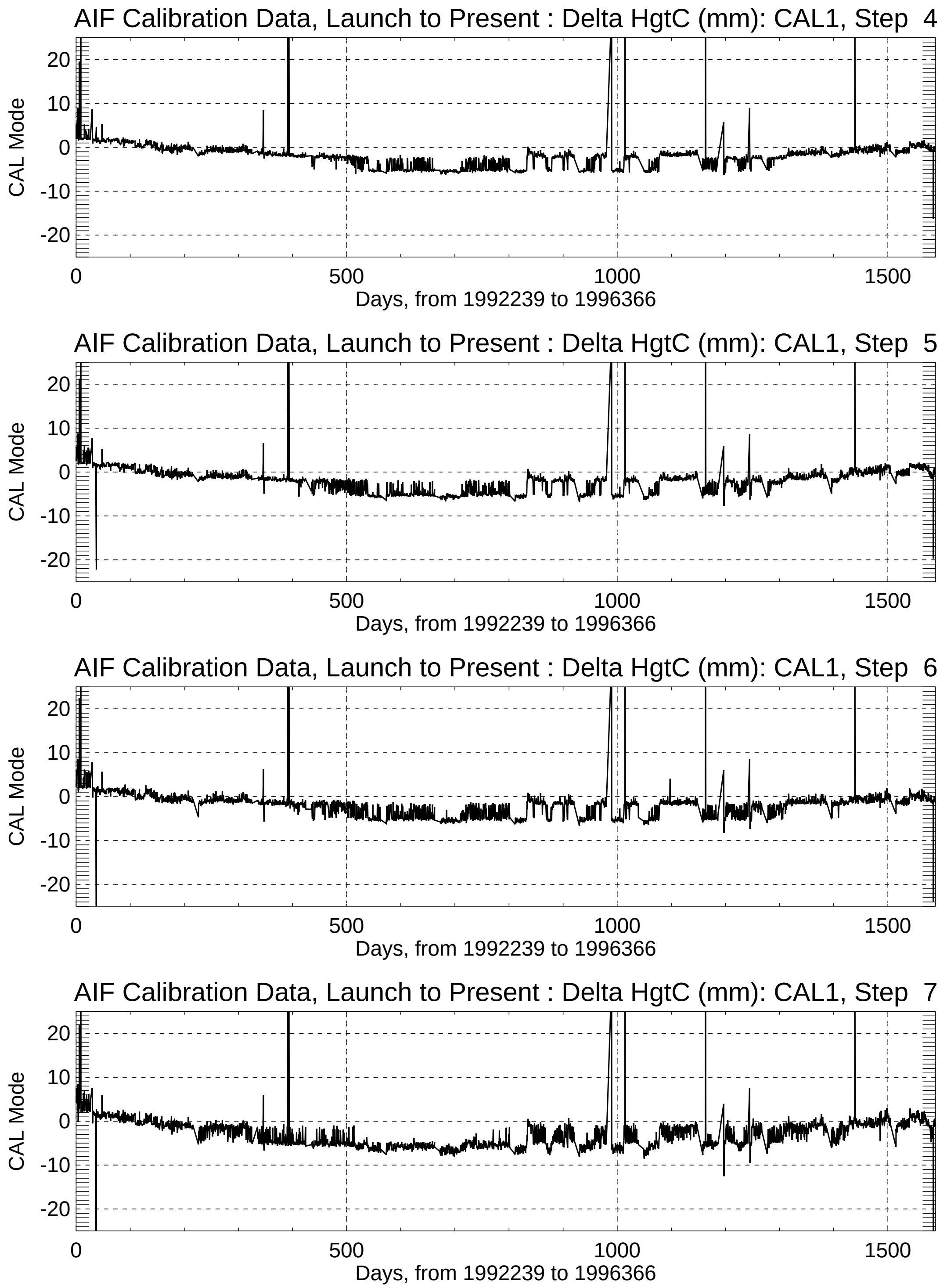


Figure 2-2 C-Band Range CAL-1 Results

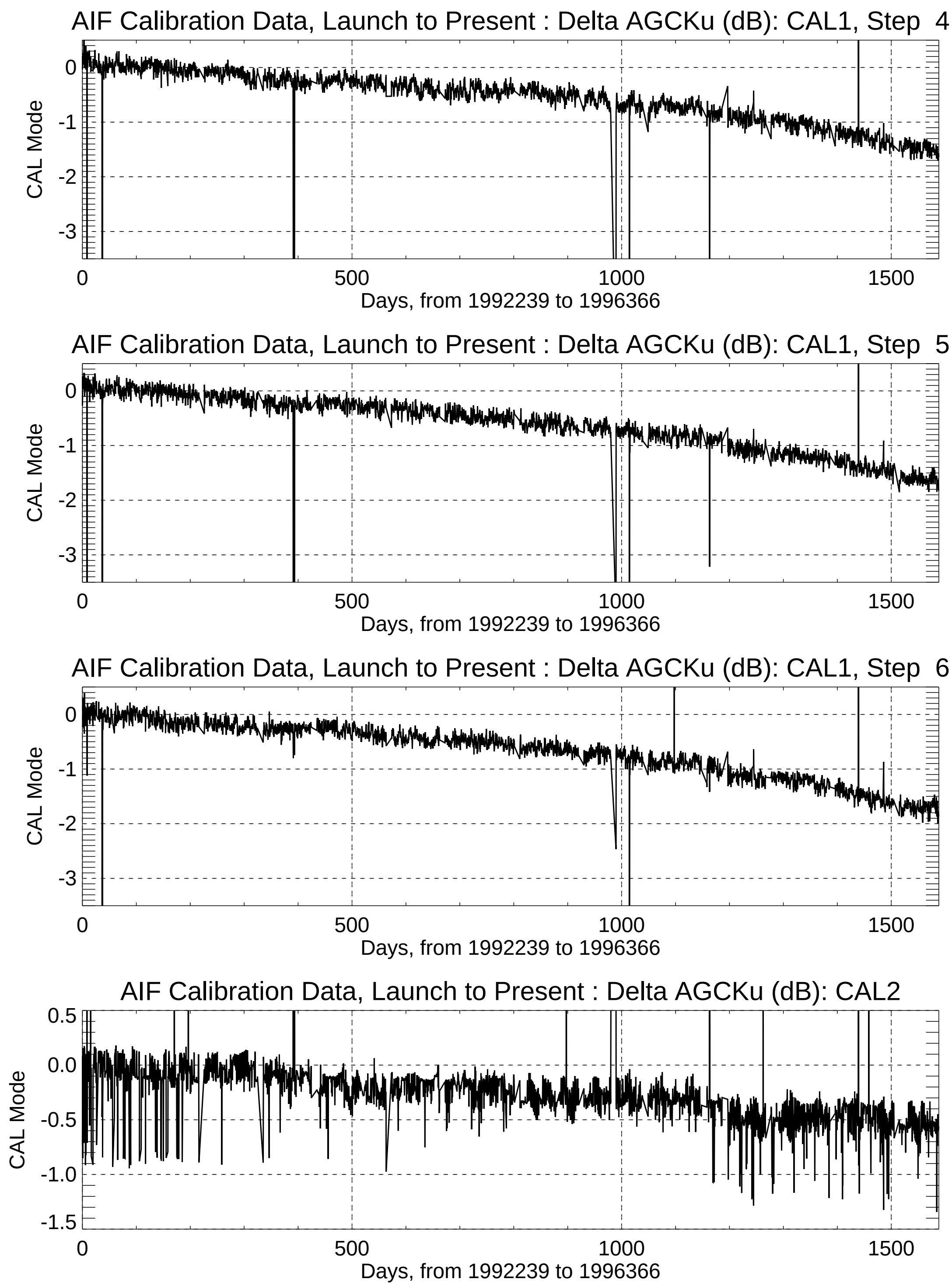


Figure 2-3 Ku-Band AGC CAL-1 and CAL-2 Results

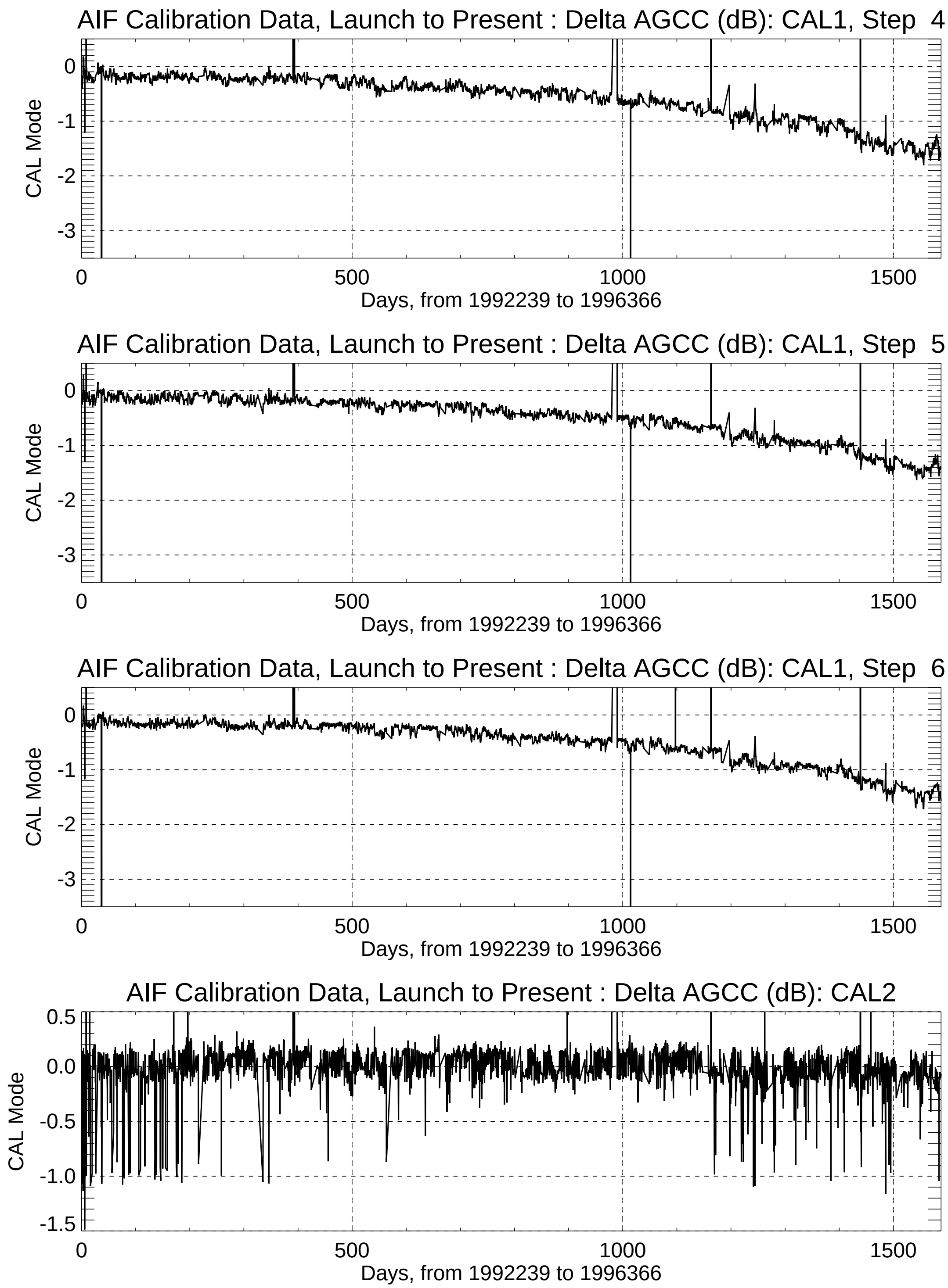


Figure 2-4 C-Band AGC CAL-1 and CAL-2 Results

2.1.2.2 CAL2 Differences over Water and Land

In the CAL-2 plots, for both Ku- and C-Band, there are occasional AGC decreases of approximately 0.9 dB. These decreases are more prevalent early in the mission, and again during the past year.

An examination of the early-mission CAL-2 calibrations with decreased signal levels uncovered the fact that they generally occurred over open ocean. Whenever the calibrations were over land areas, the AGC levels were normal.

The conclusion was that the decreases in power during CAL-2 are directly attributable to the type of surface directly below the altimeter. In CAL-2, the receive path is through the antenna, and higher passive emissions occur over land areas. Based on standard radiometric equations, the nominal emission difference between land and water is 0.83 dB, very close to the observed power difference. This CAL-2 study is documented in the TOPEX/Poseidon Research News (Hancock, et al, 1995)

2.2 Launch-to-Date Cycle Summaries

The data in the launch-to-date cycle summary plots which follow are extracted from the Geophysical Data Record (GDR) database at WFF. The criteria for TOPEX GDR measurements to be accepted for the WFF database are: 1) the data are classified as Deep Water, 2) the data are in normal Track Mode, and 3) selected data quality flags are not set.

For each measurement type, the plots contain one average measurement per cycle. The cycle average value is itself the mean of one-minute along-track boxcar averages, after editing. Data are excluded from the averaging process whenever the one-minute-averaged off-nadir angle exceeds 0.12 degree or the averaged Ku-Band sigma-naught exceeds 16 dB or whenever the number of non-flagged frames within the one-minute interval is fewer than 45. As a result of this edit, approximately 15% of the database measurements are excluded from the averaging process. This tight editing is part of our effort to ensure that anomalous data are excluded from the performance assessment process.

Investigators should use the NASA radar altimeter (ALT) data products for data cycles 1-8 with great care. The reasons for this statement are described in Section 2.2 of last year’s Engineering Assessment Report.

2.2.1 Sea Surface Height

The sea surface heights (ssh) contained in the GDR files are based on combined heights. Cycle-average ssh are shown in Figure 2-5 "Cycle-Average Sea Surface Heights, in Meters, from the WFF TOPEX GDR Database" on page 2-8. It is not possible to discern range drifts at the millimeter level from these data, but seasonal variations of sea level are observable.

Beginning with cycle 17, ssh has a 37-cycle periodicity. For example, lower ssh levels during cycles 25 through 35 are echoed during cycles 62 through 72, again during cycles 99 through 109, and again during cycles 136 through 146. Higher ssh levels are

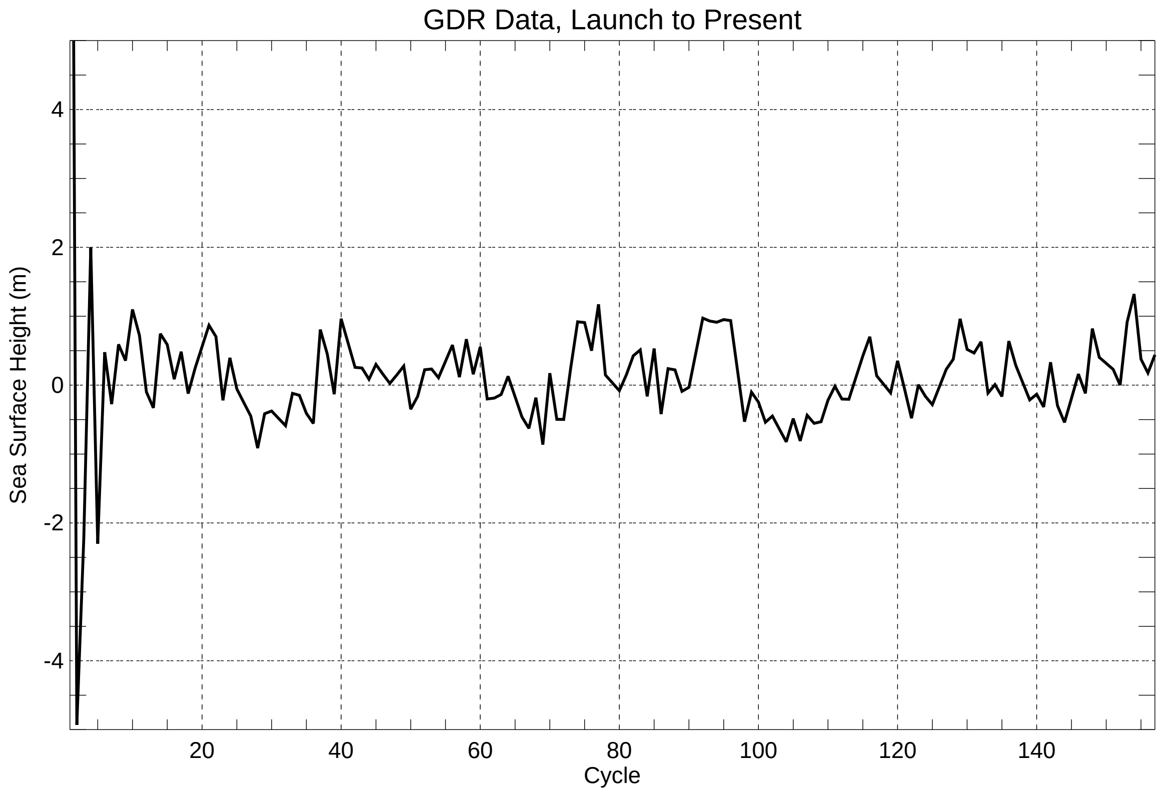


Figure 2-5 Cycle-Average Sea Surface Heights, in Meters, from the WFF TOPEX GDR Database

observed during cycles 37 through 43, during cycles 74 through 80, during cycles 111 through 117, and again during cycles 148 through 154. A 37-cycle repeatability is anticipated because, with each cycle lasting 9.916 days, there are approximately 37 (36.83) cycles per annum. Repeatability is not expected before cycle 17 because, prior to this, the NASA altimeter was not in TRACK mode for full cycles. This expected periodicity lends credence that the altimeter data remain internally consistent.

The only calibration correction applied to date to range is the +100 mm added to C-Band range shortly after launch. This correction was described in Section 5.1.2 of the February 1994 Engineering Assessment Report.

2.2.2 Sigma-Naught

The sigma-naught cycle-averages, after adding the non-temperature-corrected sigma-naught corrections (discussed later in Section 3.2), are plotted in Figure 2-6 "Cycle-Average Ku-Band Sigma-naught, in dB, from the WFF TOPEX GDR Database" on page 2-9 and Figure 2-7 "Cycle-Average C-Band Sigma-naught, in dB, from the WFF TOPEX GDR Database" on page 2-10, for Ku-Band and C-Band, respectively.

From cycle 17 to the present, Ku-Band sigma-naughts, after correction, have remained within a window of 11.20$\pm$0.20 dB and C-Band sigma-naughts have remained at 14.80$\pm$0.20 dB. There are apparent annual cycles in the sigma-naught

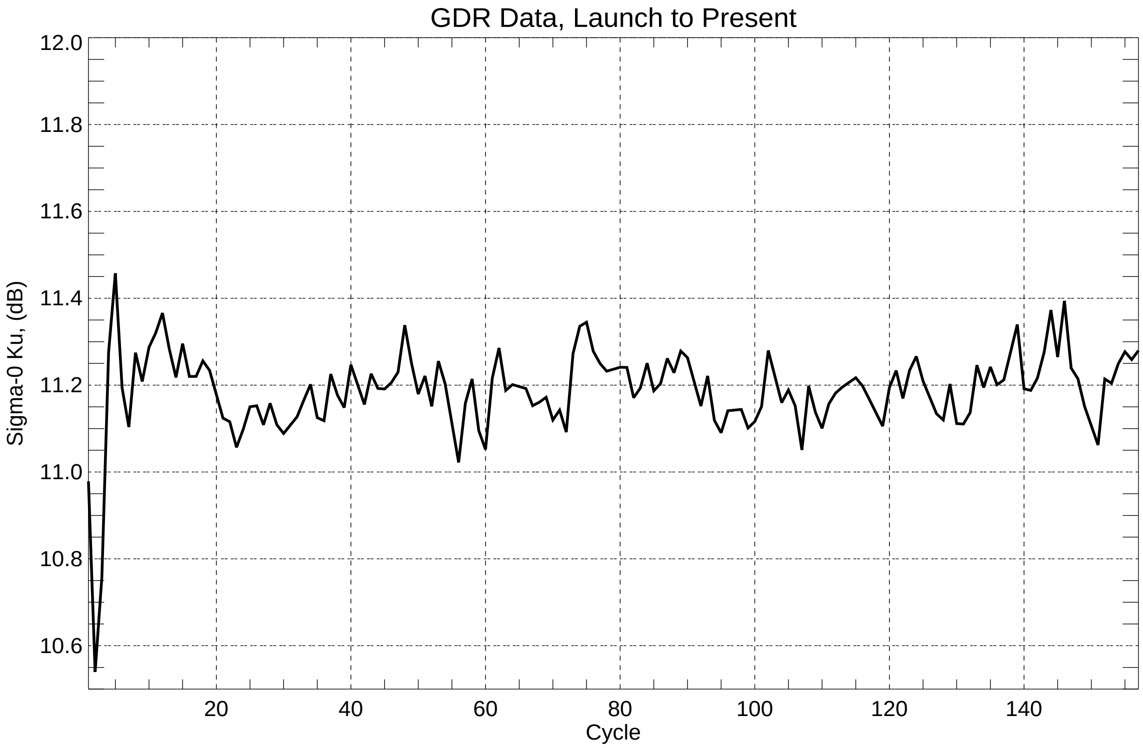


Figure 2-6 Cycle-Average Ku-Band Sigma-naught, in dB, from the WFF TOPEX GDR Database

averages, particularly in the Ku-Band (low values occur at cycles 22, 59, 96, and 133). Even with the annual effects, the sigma-naughts have remained within the pre-launch design goal for sigma-naught accuracy of $\pm$0.25 dB

2.2.3 Significant Wave Height

Ku-Band cycle-averages for significant wave height (swh) are shown in Figure 2-8 "Cycle-Average Ku-Band Significant Wave Height, in Meters, from the WFF TOPEX GDR Database" on page 2-11. Subsequent to cycle 8, the cycle-average swh's have remained in the range of 2.8+0.3 m, with no apparent long-term drift. As anticipated, the Ku-Band swh values are inversely correlated (i. e., high swh are associated with low sigma-naught, and vice-versa) with the Ku-Band sigma-naughts shown in Figure 2-6.

There appears to be an annual cycle in the data, with particularly low swh's (2.5-2.6 m) centered around cycles 11, 48, 85, and 122, gradually building up to 3.0-3.1 m swh centered around cycles 23, 60, 97, and 134. Cycles 11, 48, 85, and 122 occurred in early January 1993, January 1994, January 1995, and January 1996, respectively, corresponding to summer in the southern hemisphere. Cycles 23, 60, 97, and 134 were in early May 1993, May 1994, May 1995, and May 1996, respectively, corresponding with early fall in the southern hemisphere. The southern hemisphere is referred to here because there is a considerably higher percentage of the total ocean area south of the equator.

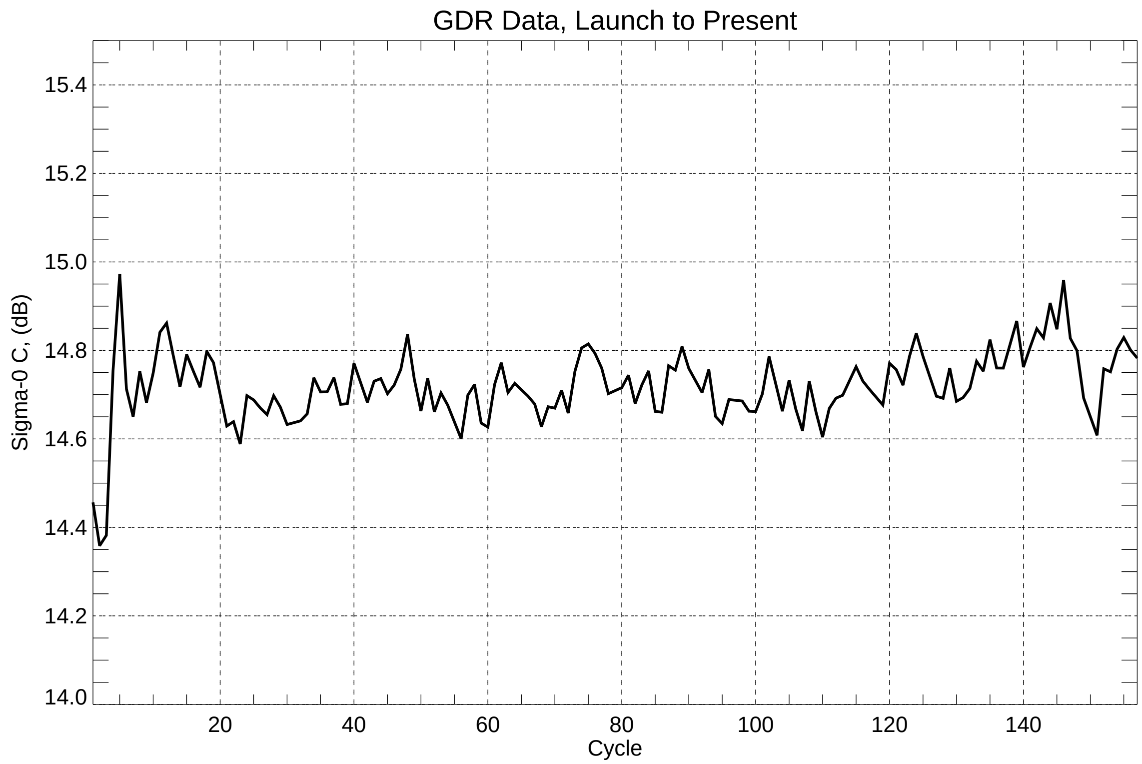


Figure 2-7 Cycle-Average C-Band Sigma-naught, in dB, from the WFF TOPEX GDR Database

2.2.4 Range RMS

The calculated Ku-Band range rms values depicted in Figure 2-9 "Cycle-Average Ku-Band Range RMS, in Millimeters, from the WFF TOPEX GDR Database" on page 2-12 are based on the rms derivation described in Section 5.1.1 of the February 1994 Engineering Assessment Report. Subsequent to cycle 17, the rms values have remained in a narrow band of 18.5$\pm$0.9 mm, and are observed to be directly correlated with the swh's in Figure 2-8; the higher the SWH, the higher the rms. There has been no apparent change in range RMS since launch.

2.2.5 Waveform Monitoring

Selected telemetered waveform gates during CAL-2 and STANDBY modes are monitored daily, to discern waveform changes throughout the mission. CAL-2 waveform sets are generally available twice per day, during calibrations. STANDBY waveforms are generally available four times per day, since the altimeter passes through STANDBY mode just prior to and immediately after CALIBRATE mode. The relationship of telemetered waveform sample numbers to the onboard waveform sample numbers is listed in Table 6.2.1 of the February 1994 Engineering Assessment Report.

For both Ku-Band and C-Band, the monitored waveform samples are as follows: CAL-2 gates 23, 29, 48, and 93; and STANDBY gates 38, 39, 68, and 69. The Ku-Band waveform sample history is shown in Figure 2-10 "Ku-Band CAL-2 Waveform Sample History" on page 2-13 and Figure 2-11 "Ku-Band STANDBY Waveform Sample

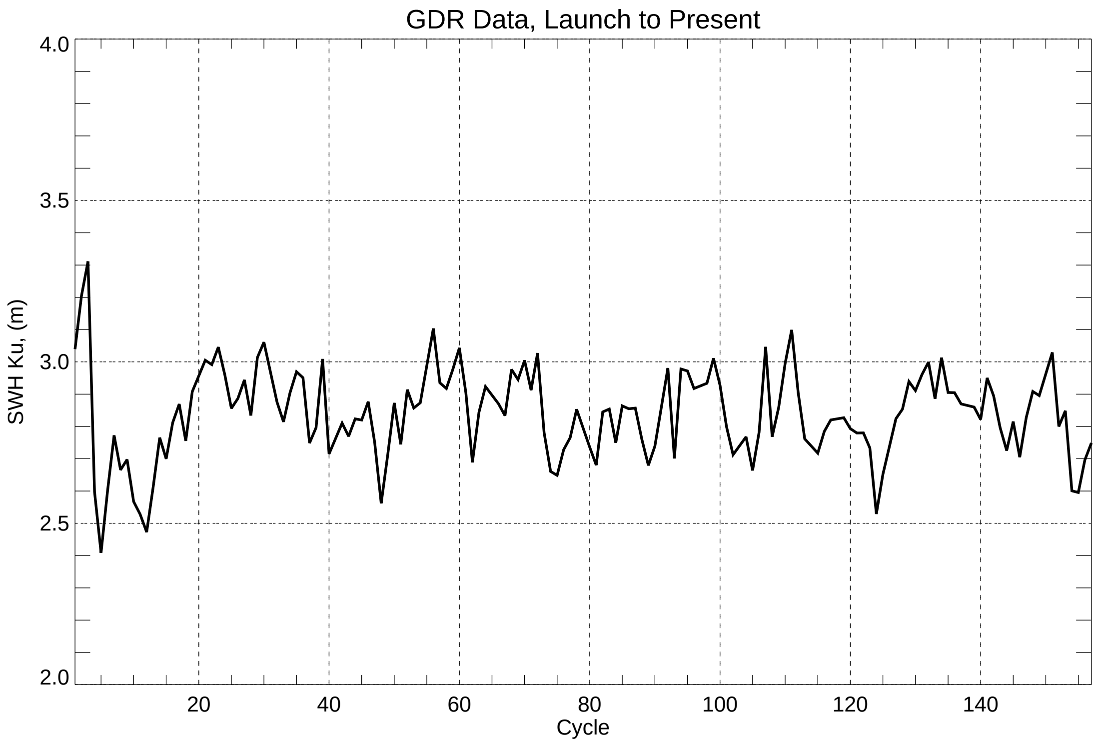


Figure 2-8 Cycle-Average Ku-Band Significant Wave Height, in Meters, from the WFF TOPEX GDR Database

History" on page 2-14 for CAL-2 and STANDBY, respectively. The C-Band waveform history is depicted in Figure 2-12 "C-Band CAL-2 Waveform Sample History" on page 2-15 and Figure 2-13 "C-Band STANDBY Waveform Sample History" on page 2-16, respectively, for CAL-2 and STANDBY.

The monitored Ku-Band CAL-2 waveform samples in Figure 2-10 have each varied less than 1% throughout the mission, and exhibit little or no temperature dependence.

The Ku-Band STANDBY waveform samples in Figure 2-11, however, have fluctuated during the mission. The power in gate 38 has a very noticeable inverse dependence on temperature (selected launch-to-date temperatures are shown in Figure 2-14, on the same horizontal time scale as the waveform samples). Gate 39 is also observed to have an inverse temperature dependence and, in addition, has had about a 50% reduction in power since launch; this large power reduction is of interest to us, but does not appear to be adversely affecting altimeter performance. Gate 68 has a slight inverse dependence on temperature, and has had a small (5%) decrease in power. Gate 69 also has a modest temperature dependence, and its power level has decreased a total of about 20% during the mission.

The C-Band CAL-2 waveforms samples, shown in Figure 2-12, are similar to the Ku-Band CAL-2 waveforms in that they have varied less than about 1%, and exhibit no apparent temperature dependence.

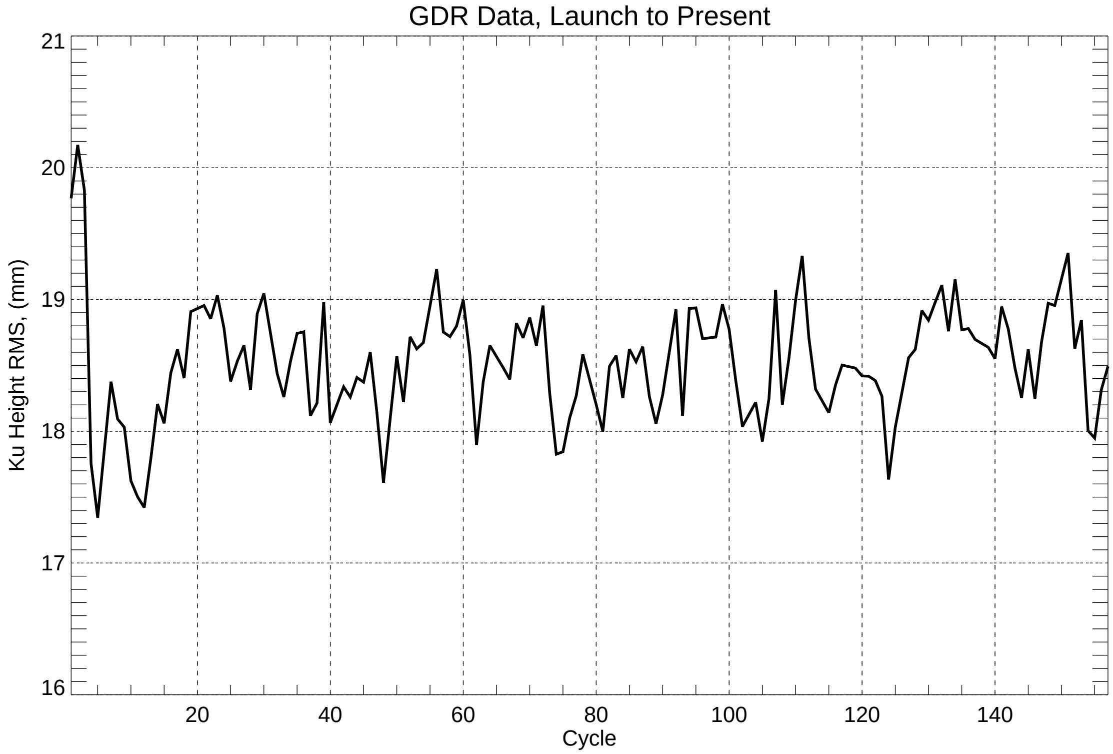


Figure 2-9 Cycle-Average Ku-Band Range RMS, in Millimeters, from the WFF TOPEX GDR Database

The C-Band STANDBY waveform samples, shown in Figure 2-13, are also similar to their counterpart Ku-Band STANDBY waveforms. Gates 38, 39, 68, and 69 have an inverse dependence on temperature. Gate 39 has experienced about a 45% decrease in power since launch, gate 68 has decreased in power about 8%, and gate 69 has decreased approximately 25%. The rate of decrease for each of these three gates was smaller during 1995 and 1996 than for the prior years.

2.2.6 Engineering Monitors

Altimeter temperatures, voltages, powers and currents continue to be monitored. The system remains very stable, with no significant changes since launch.

The engineering monitor plots presented in this section contain data based on one-hour time periods, showing: the average, the minimum, and the maximum values during each hour.

2.2.6.1 Temperatures

The temperatures of all 26 internal thermistors continue to be within the design temperature range and are within the ranges used during the pre-launch Hot and Cold Balance Tests. The minimum / maximum values for each of the thermistors during TRACK mode remain within the bounds listed in Table 7.1 of the February 1994 Engineering Assessment Report.

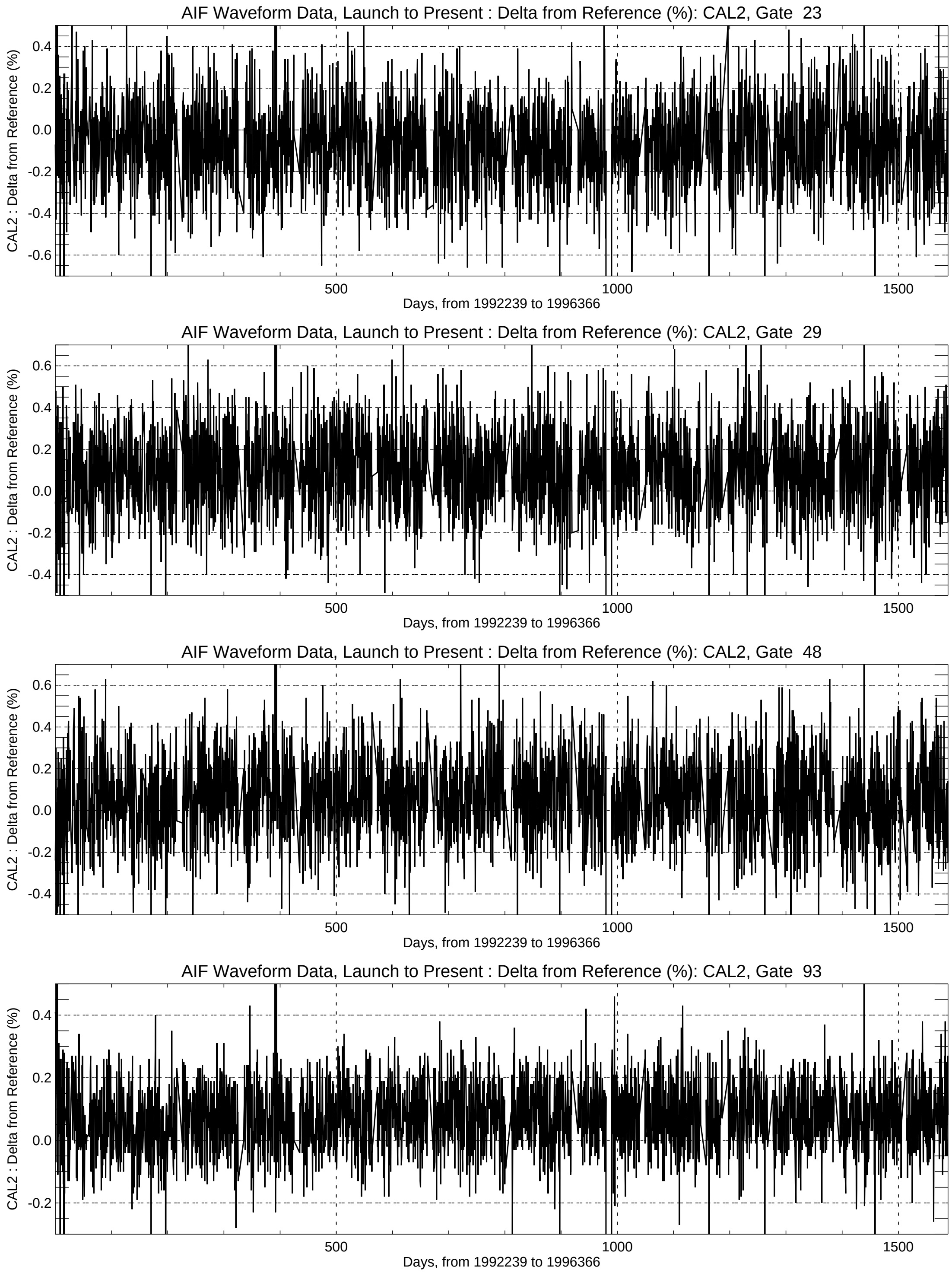


Figure 2-10 Ku-Band CAL-2 Waveform Sample History

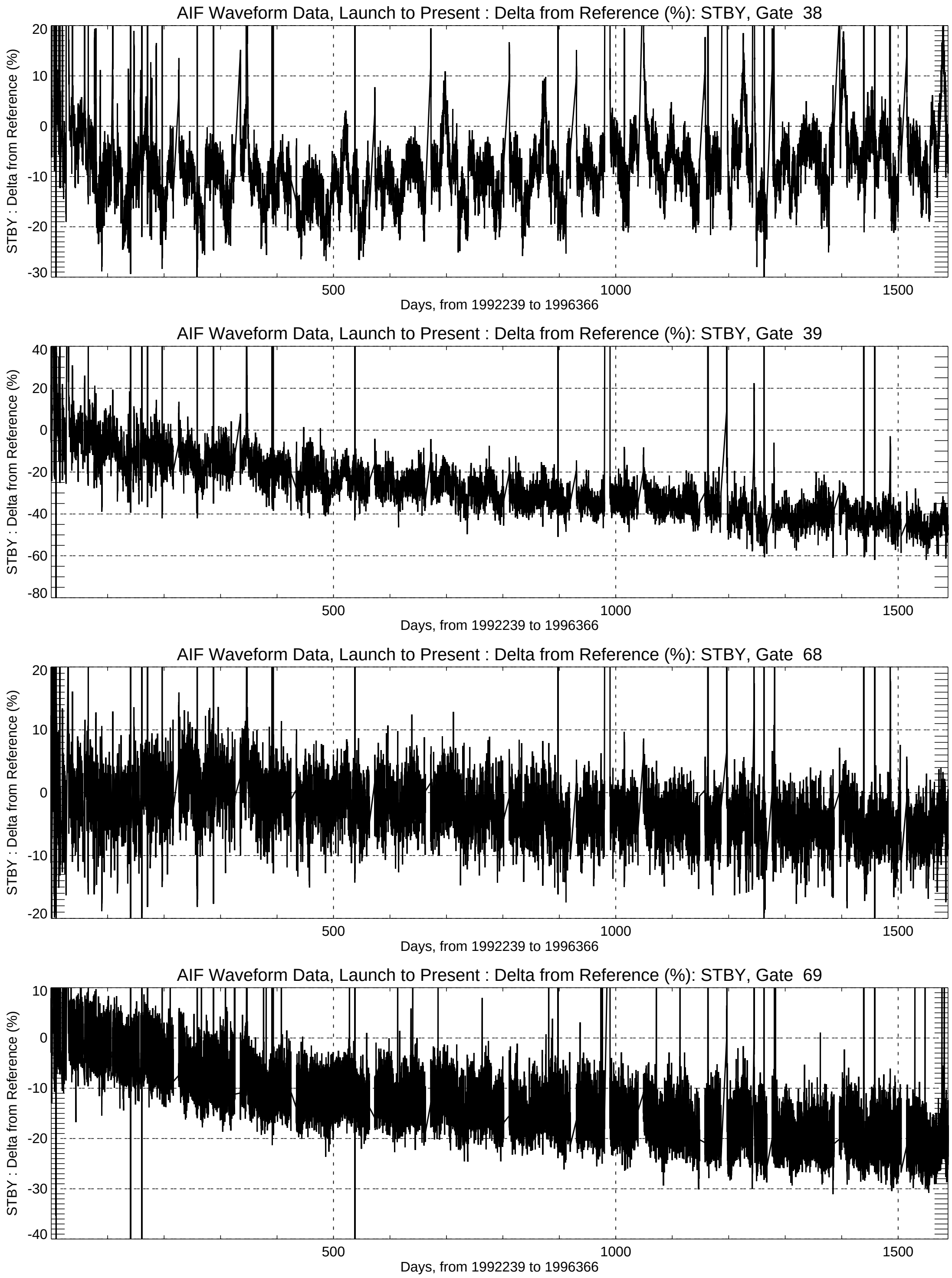


Figure 2-11 Ku-Band STANDBY Waveform Sample History

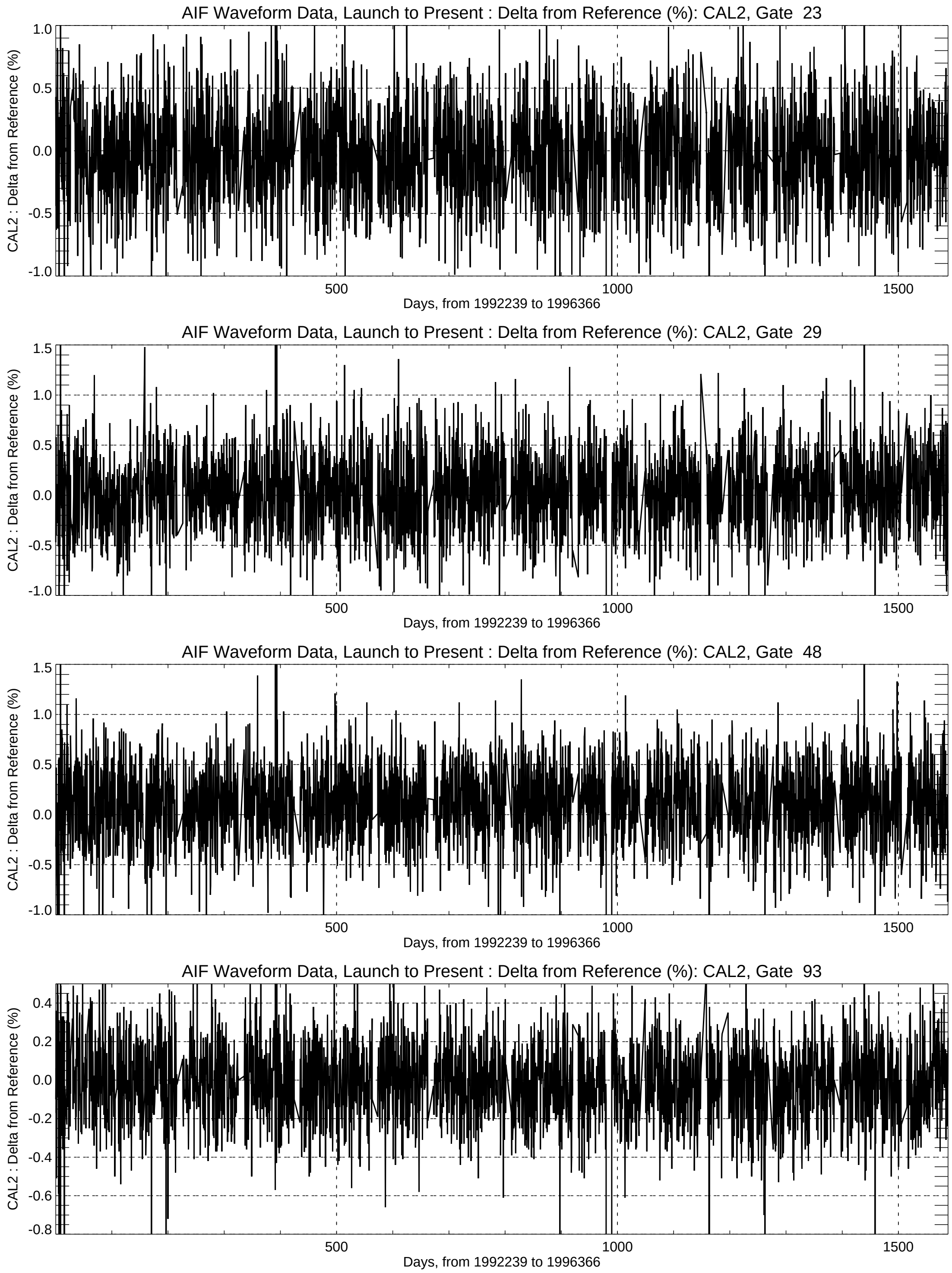


Figure 2-12 C-Band CAL-2 Waveform Sample History

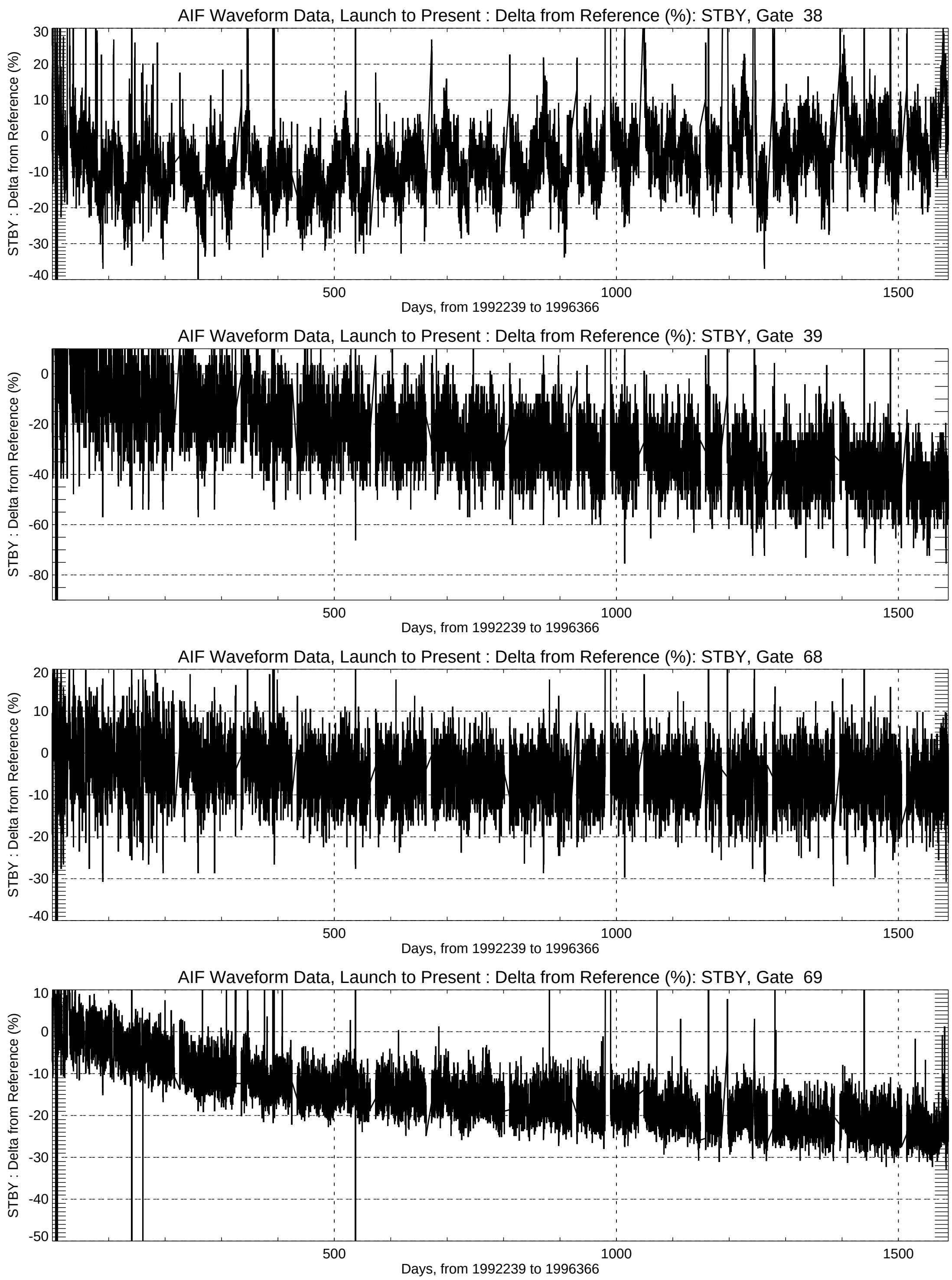


Figure 2-13 C-Band STANDBY Waveform Sample History

Three sample launch-to-date temperature histories (DCG Gate Array, LVPS Mount Plate, and LVPS Boost Regulator) compose the first three plots in Figure 2-14 "Engineering Monitor Histories". All the other thermistors follow the same temperature pattern.

Although not used during our routine monitoring, several of the altimeter-related baseplate temperature monitors serviced by Remote Interface Unit (RIU) 6B became uncalibrated on day 17 of 1995. The affected temperature monitors are listed in Section 2.2.6.1 of last year's Engineering Assessment Report. An abrupt change in the values occurred on that date, apparently due to a change in the current which is applied to the thermistor circuits

2.2.6.2 Voltages, Powers and Currents

The altimeter's 17 monitors for voltages, powers and currents remain at consistent levels, with little deviations. Their launch-to-date histories are also shown in Figure 2-14 "Engineering Monitor Histories" on page 2-18.

The eight voltages [LVPS +12V, LVPS +28V, LVPS +15V, LVPS -15V, LVPS +5V(5%), LVPS +5V(1%), LVPS -5.2V and LVPS -6V], have changed very little from the minimum / maximum values listed in Table 7.2 of the February 1994 report. Four of the voltages (LVPS +12V, LVPS +28V, LVPS +15V and LVPS -5.2V) exhibit more bit toggling than they did early in the mission, while the LVPS -15V and the LVPS +5V(5%) are toggling less. LVPS -15V has had a slight (0.07V) decrease since launch, and LVPS +5V(1%) has had an even smaller (0.005V) decrease.

The Ku-Band Transmit Power generally increased about 0.2 watt at the beginning of the year, and remained at that level throughout 1996. Although not shown on the plot, the Ku-Band Transmit Power decreased 0.2 watt at the beginning of 1997, so that it has since returned to its pre-1996 level. We have observed the effects of occasional bit toggling, or "clicking," in the Ku transmit power monitor. The nature of the clicking is that the monitored power will decrease either 1, 2, 3 or 4 bits (a bit is equivalent to about 0.123 watt) for a few minutes, and then step back up to its nominal value. These observed short-duration power changes, whether real or not, do not appear to affect the altimeter performance; we continue to monitor the power changes.

The C-Band Transmit Power decreased about 0.1 watt during the year, and its level is now about 0.5 watt lower than its initial on-orbit level.

There are no observed changes in the operating levels of the TWTA Cathode voltage, TWTA Cathode amperage, TWTA Helix current, or CSSA Input RF power. There continues to be gradual decrease in the CSSA Bus current level; the level has now decreased 0.07 amp since launch. There have been gradual increases in the maximum levels of both the TWTA Bus current and the LVPS Bus current; the increases have been 0.06 amps and 0.2 amps, respectively, since launch.

2.2.7 Single Event Upsets

There have been a total of 212 Single Event Upsets (SEUs) from launch to the beginning of 1997. The vast majority of them occurred in the South Atlantic Anomaly, as

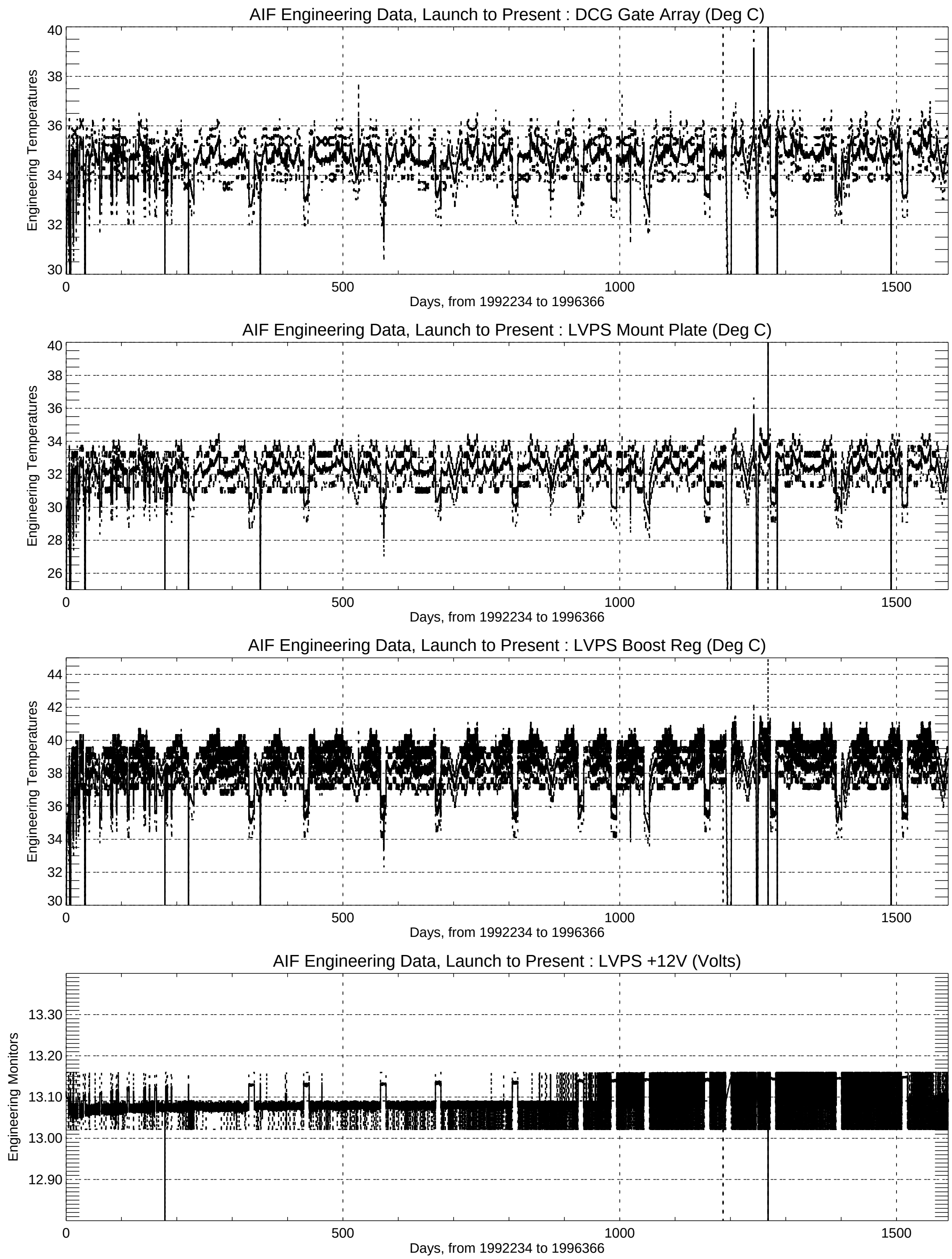


Figure 2-14 Engineering Monitor Histories

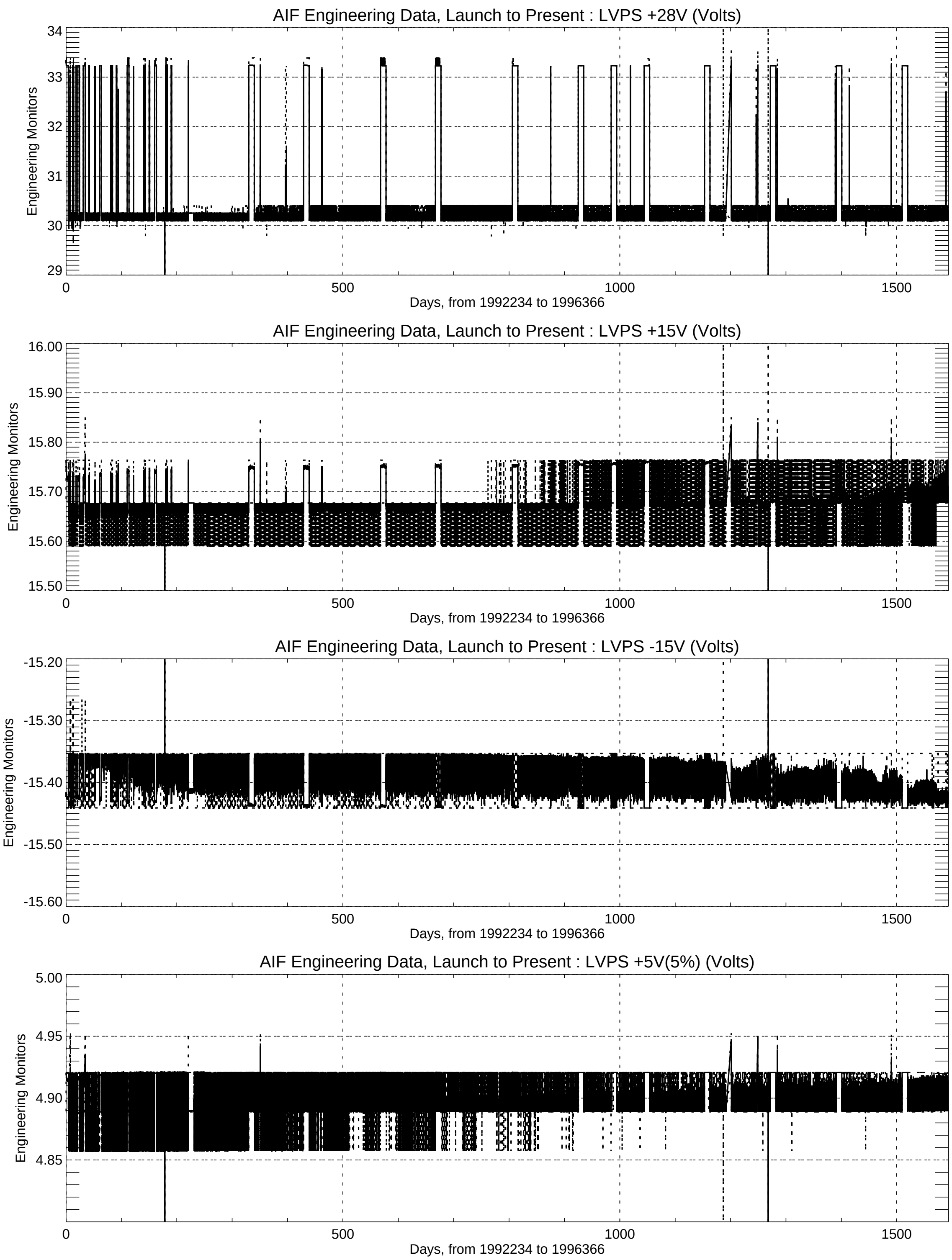


Figure 2-14 Engineering Monitor Histories (Continued)

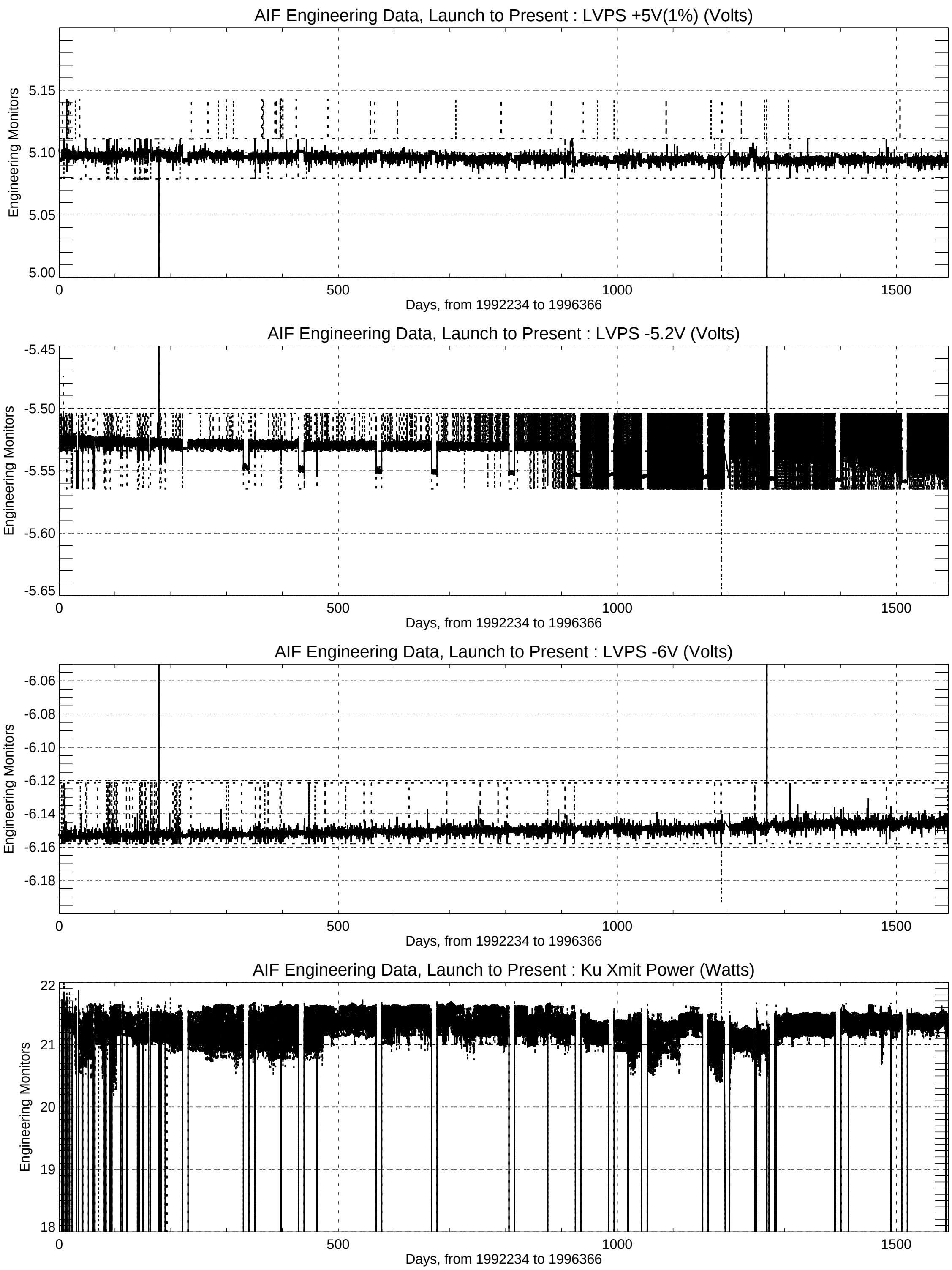


Figure 2-14 Engineering Monitor Histories (Continued)

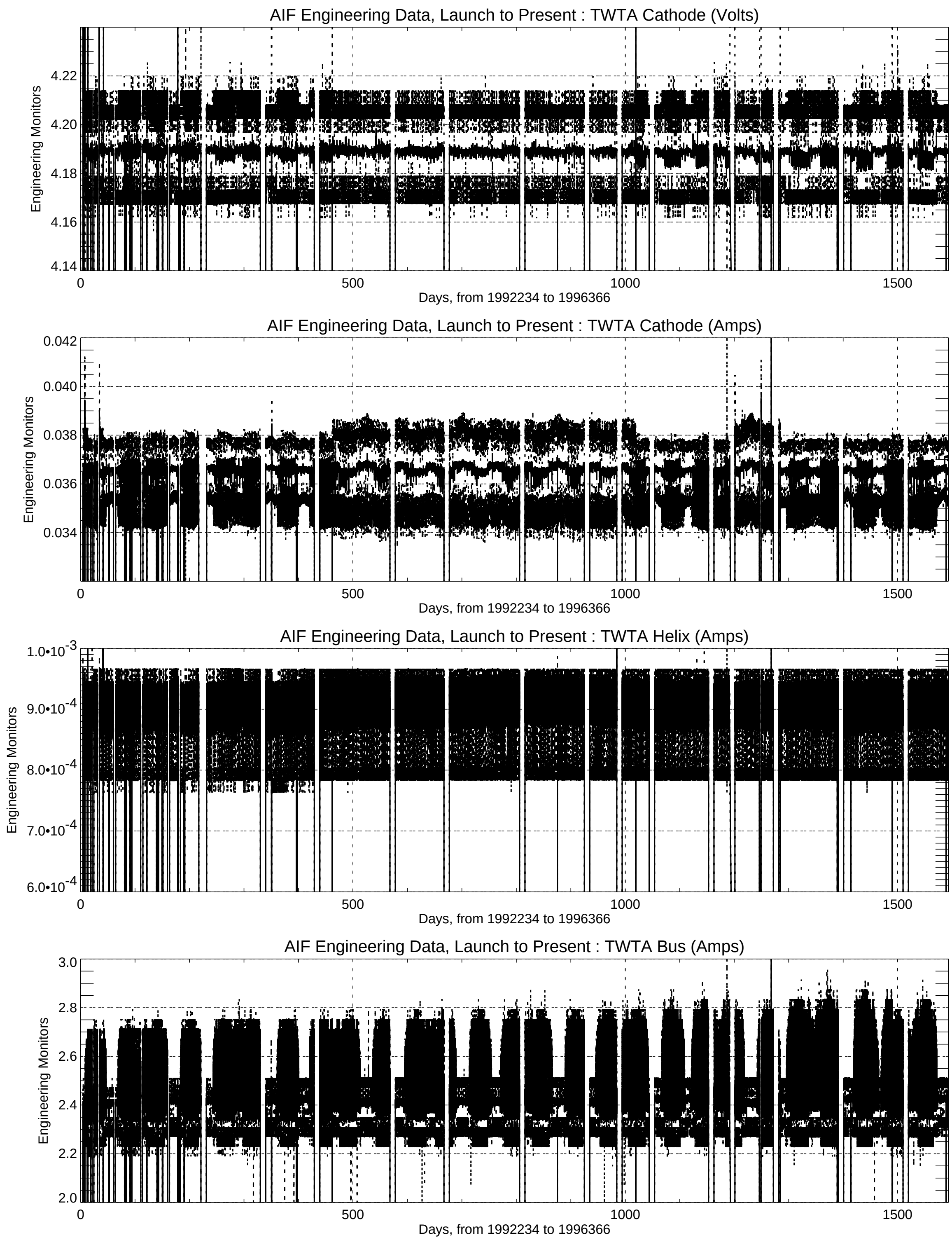


Figure 2-14 Engineering Monitor Histories (Continued)

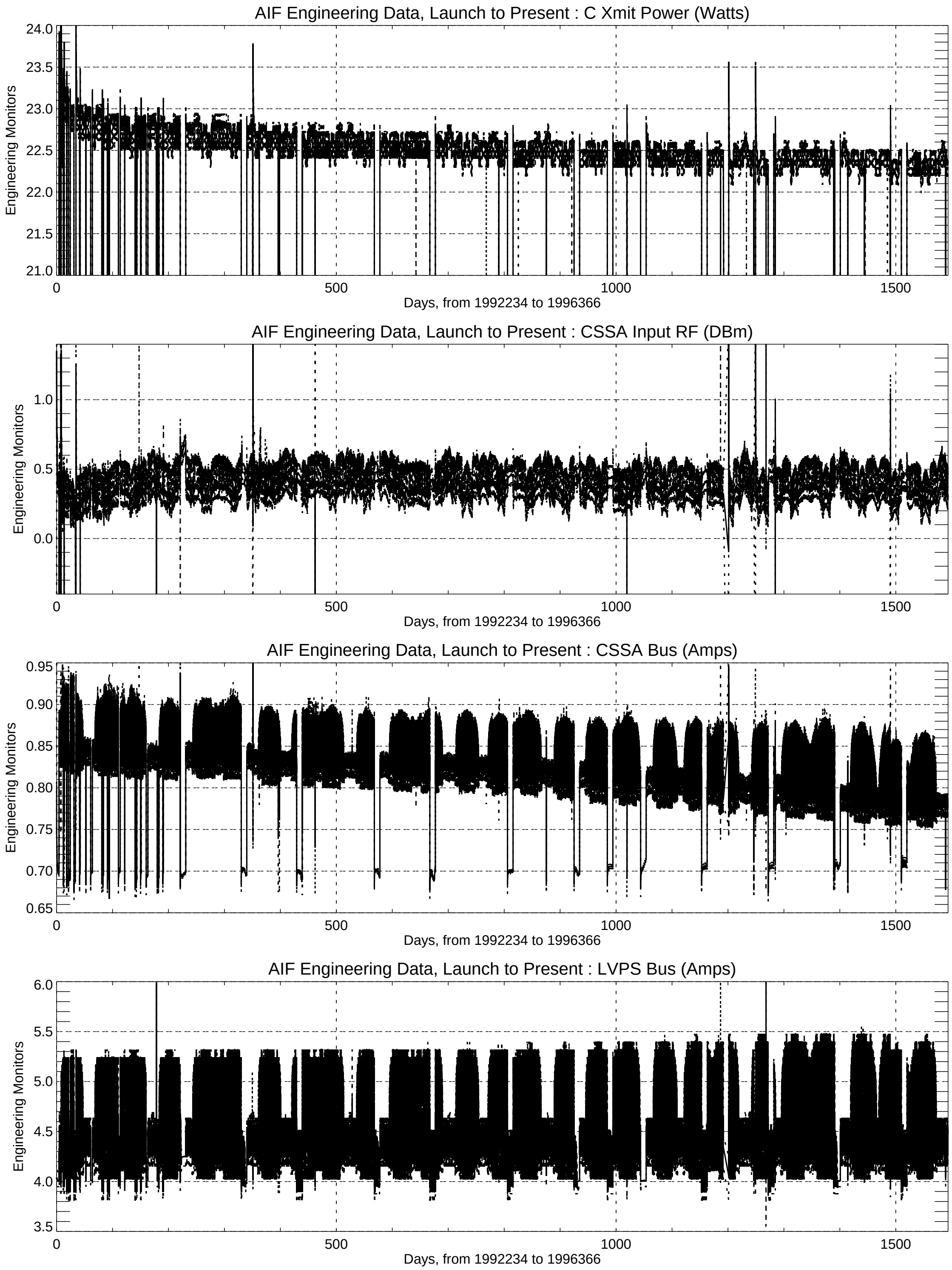


Figure 2-14 Engineering Monitor Histories (Continued)

shown in Figure 2-15 "Locations of SEU Occurrences" on page 2-24. The altimeter processor automatically recovered from 187 of the SEUs; the other 25 required manual (ground-based command) resets. While the automatic resets generally resulted in the loss of only a few seconds of data, nine of them had data effects of longer duration. As of January 1, 1997, there have been a total of 34 anomalous resets (24 manual resets plus the 9 abnormal automatic resets); Table 2-1 "Anomalous Single Event Upsets" lists the dates of these 34 SEUs, along with the type of on-board reset and the duration of the effect on the data.

Table 2-1 Anomalous Single Event Upsets

Year	Day	Duration (Hr)	Reset Type
1992	247	11.0	Automatic
1992	354	16.8	Manual
1993	012	0.5	Automatic
1993	230	1.3	Automatic
1993	264	14.5	Manual
1993	266	7.5	Manual
1993	307	2.3	Manual
1993	330	8.3	Manual
1994	001	3.8	Manual
1994	112	1.1	Manual
1994	256	4.3	Manual
1994	271	0.1	Automatic
1994	288	2.5	Manual
1994	294	1.3	Automatic
1994	324	3.1	Manual
1995	012	0.7	Automatic
1995	083	1.6	Manual
1995	132	0.2	Manual
1995	157	8.4	Manual
1995	251	3.9	Manual
1995	306	3.4	Manual
1995	325	1.8	Manual
1995	327	3.5	Manual
1995	361	3.3	Manual

Table 2-1 Anomalous Single Event Upsets (Continued)

Year	Day	Duration (Hr)	Reset Type
1996	018	2.0	Automatic
1996	041	3.1	Manual
1996	057	2.2	Manual
1996	077	1.6	Manual
1996	162	0.8	Automatic
1996	185	0.7	Automatic
1996	197	1.1	Manual
1996	217	2.8	Manual
1996	226	4.9	Manual
1996	362	4.8	Manual
		Total = 129.2 Hours	

The dots in Figure 2-15 denote the locations of normal SEU occurrences, while the diamonds indicate that the SEU was abnormal.

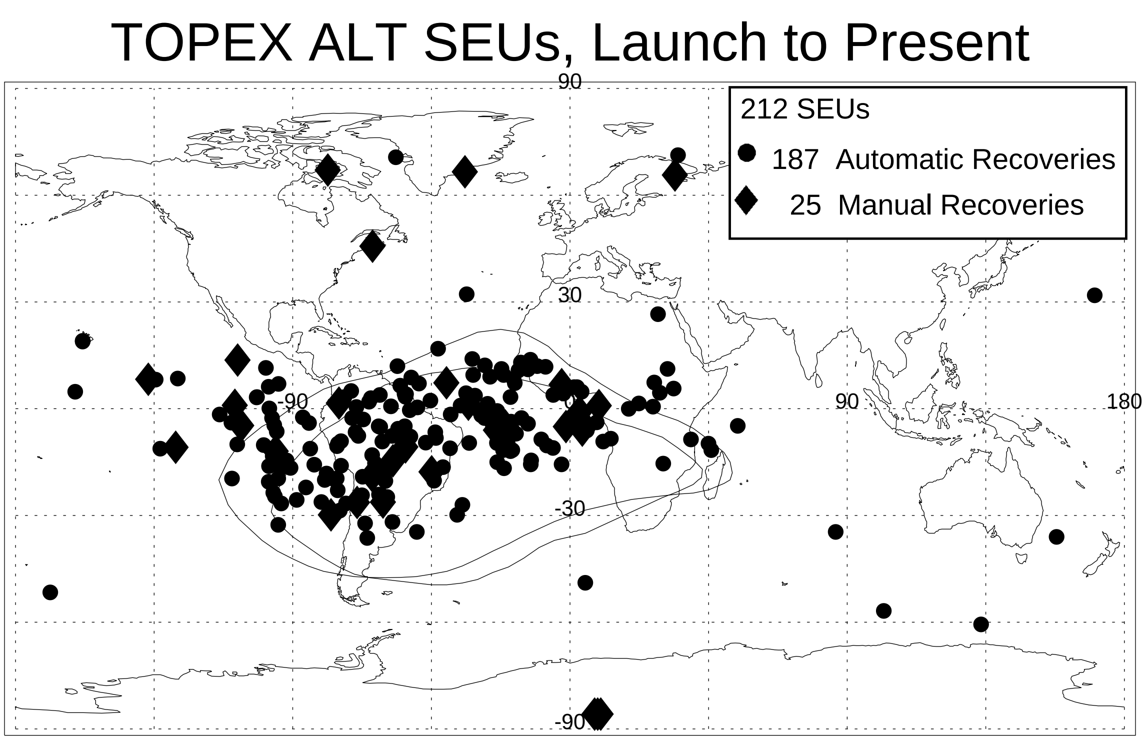


Figure 2-15 Locations of SEU Occurrences

The three diamonds at latitude -90 degrees were placed there because their occurrence times (and corresponding geographic locations) could not be pin-pointed due to the altimeter being in IDLE mode, and because procedures had not, at that time, been implemented to record the IDLE-mode SEU times.

There were a total of 58 SEUs during 1996, or about one every 6.3 days. For the total mission, the SEU occurrence average has been one every 7.5 days.

There were ten anomalous SEUs in 1996; for seven of them, the TOPEX/POSEIDON POCC reset the altimeter by transmitting Command Block SA28 (Processor Error Reset in Track Mode). The other three SEUs required specialized commanding; those three events were:

a) Day 018 - The SEU reset was automatic, but scratch pad memory for both the science and engineering frames was corrupted. The memory was reestablished via ground commands on day 019. These commands restored all memory to normal values. The data quality, in the interim between the SEU and the memory reset, was apparently not affected. This memory corruption period of time will be manifested on the Sensor Data Record by bit 3 (Spare Exception) being set in both the Alt_Sci_Prelim_Flags and the Alt_Eng_Prelim_Flags.

b) Day 185 - This anomaly was similar to day 018 in that the SEU reset was automatic, but the science frame scratch pad memory was corrupted. The memory problem was corrected by ground commands on day 187. The data quality was apparently not affected. This memory corruption period of time will be manifested on the Sensor Data Record by bit 3 being set in Alt_Sci_Prelim_Flags.

c) Day 362 - This SEU resulted in the C MTU transmit side being switched from Side A to Side B. The A/B MTU switch was toggled by ground command later that day, rectifying the problem. The Ku-Band data in the interim were usable, but the C-Band data were not; the lack of valid dual-frequency measurements prevents the calculation of ionospheric corrections. A memorandum addressing this Side toggling, from David Hancock to John Hultberg, comprises Attachment A of this report.

2.3 Launch-to-Date Key Events

The launch-to-date key events for the TOPEX Radar Altimeter are summarized in Table 2-2 "NASA Altimeter - Key Events".

Table 2-2 NASA Altimeter - Key Events

Day	Event
92/234	Altimeter Turned On to IDLE Mode
92/238	First TRACK
92/240	Safehold During Inclination Maneuver

Table 2-2 NASA Altimeter - Key Events (Continued)

Day	Event
92/242	Returned to TRACK Mode
92/242	Turned Off by TMON at Start of Eclipse
92/242	Returned to TRACK Mode
92/247	Improper SEU Recovery due to Corruption of Pulse Count Variable
92/268	Safehold
92/269	Returned to TRACK Mode
92/304	50ms Acquisition Parameter Set Upload
92/328	Software Patch to Refresh Pulse Count (see Day 247 above)
92/354	Loss of Science Data and Clock Between SEUs (lost 16 hours of data)
93/012	Improper SEU Recovery (lost 12 min. of data)
93/089	Turned Off by TMON
93/089	Returned to TRACK Mode
93/089	Changed to IDLE Mode for SSALT
93/099	Returned to TRACK Mode
93/198	Changed to IDLE Mode for SSALT
93/208	Returned to TRACK Mode
93/218	Turned Off by TMON
93/219	Returned to TRACK Mode
93/230	Improper SEU Recovery (lost 1.5 hours of data)
93/264	Improper SEU Recovery (lost 14.5 hours of data)
93/266	Improper SEU Recovery (lost 7.5 hours of data)
93/297	Changed to IDLE Mode for SSALT
93/307	Returned to TRACK Mode
93/307	Improper SEU Recovery (lost 2.3 hours of data)
93/330	Improper SEU Recovery (lost 8.2 hours of data)
94/001	Improper SEU Recovery (lost 3.7 hours of data)
94/071	Changed to IDLE Mode for SSALT
94/081	Returned to TRACK Mode
94/112	Improper SEU Recovery (lost 1.1 hours of data)
94/170	Changed to IDLE Mode for SSALT

Table 2-2 NASA Altimeter - Key Events (Continued)

Day	Event
94/180	Returned to TRACK Mode
94/256	Improper SEU Recovery (lost 4.3 hours of data)
94/288	Improper SEU Recovery (lost 2.5 hours of data)
94/294	Improper SEU Recovery (lost 1.3 hours of data)
94/309	Changed to IDLE Mode for SSALT
94/319	Returned to TRACK Mode
94/324	Improper SEU Recovery (lost 3.1 hours of data)
95/012	Improper SEU Recovery (lost 0.7 hours of data)
95/040	Changed Operating Parameter Set for Faster Acquisition after a Reset
95/063	Changed to IDLE Mode for SSALT
95/073	Returned to TRACK Mode
95/083	Improper SEU Recovery (lost 1.6 hours of data)
95/123	Changed to IDLE Mode for SSALT
95/133	Returned to TRACK Mode
95/157	Improper SEU Recovery (lost 8.4 hours of data)
95/182	Changed to IDLE Mode for SSALT
95/192	Returned to TRACK Mode
95/251	Improper SEU Recovery (lost 3.9 hours of data)
95/291	Changed to IDLE Mode for SSALT
95/301	Returned to TRACK Mode
95/306	Improper SEU Recovery (lost 3.4 hours of data)
95/325	Improper SEU Recovery (lost 1.8 hours of data)
95/327	Improper SEU Recovery (lost 3.5 hours of data)
95/330	Spacecraft Safehold (lost 230 hours of data)
95/340	Returned to TRACK Mode
95/361	Improper SEU Recovery (lost 3.3 hours of data)
96/019	Improper SEU Recovery (lost 2.0 hours of data)
96/020	Spacecraft Safehold (lost 68 hours of data)
96/040	AGC Calibration (lost 0.3 hours of data)
96/041	Improper SEU Recovery (lost 3.1 hours of data)

Table 2-2 NASA Altimeter - Key Events (Continued)

Day	Event
96/046	Changed to IDLE Mode for SSALT
96/056	Returned to TRACK Mode
96/057	Improper SEU Recovery (lost 2.2 hours of data)
96/058	Turned Off by TMON (lost 5.3 hours of data)
96/077	Improper SEU Recovery (lost 1.6 hours of data)
96/162	Improper SEU Recovery (lost 0.8 hours of data)
96/164	Changed to IDLE Mode for SSALT
96/174	Returned to TRACK Mode
96/187	Improper SEU Recovery (lost 0.7 hours of data)
96/197	Improper SEU Recovery (lost 1.1 hours of data)
96/217	Improper SEU Recovery (lost 2.8 hours of data)
96/226	Improper SEU Recovery (lost 4.9 hours of data)
96/236	Digital Filter Bank Leakage Test (lost 0.8 hours of data)
96/263	Turned off by TMON (lost 19.0 hours of data)
96/283	Changed to IDLE Mode for SSALT
96/293	Returned to TRACK Mode
96/362	C-Band Transmit on Side B (lost 4.8 hours of data)

Section 3

Assessment of Instrument Performance

3.1 Range

The following range discussion is repeated from last year's assessment update; the only change is that Table 3-1 "TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5" on page 3-2 has been updated to include 1996 data, and Figure 3-1 "Range Corrections not Modified for the Effects of Temperature" on page 3-8 and Figure 3-2 "Range Corrections which have been Temperature-Corrected" on page 3-9 have been added to more clearly depict the long-term trends. The contents of Table 3-1 are regularly updated on our TOPEX Web site, at http://osb3.wff.nasa.gov/topex/docs/RangeStabUpdate.html

The CAL-1 Step-5 Ku-Band and C-Band delta ranges have been processed to form a set of delta combined range values. There are about twenty delta combined ranges for each TOPEX data cycle, corresponding to the two calibrations per day during the 10-day cycle.

Range bias changes for the NASA radar altimeter of the TOPEX/POSEIDON mission are described by Hayne, et al (1994). Reported here are the additional bias change results to date. Table 3-1 lists values for the combined (Ku&C) delta range, in millimeters, with the same sign convention used in the October 1994 article. We made one change in Table 3-1 as of February 1996: the table now contains bias change results both with and without temperature correction. Before February 1996, the versions of Table 3-1 contained only the temperature corrected results; we are now also providing results with no temperature correction. For the TOPEX GDR data end user who does not have easy access to the temperature data, it would be more appropriate to use the combined delta range results NOT corrected for temperature.

Temperatures are measured at about two dozen different positions within the TOPEX altimeter. Because all these temperatures move up and down together, it is not possible to determine which of these temperatures is the most important to range bias, and for our analyses we use the temperature of the upconverter/ frequency multiplier (UCFM) unit; this will be designated T_u below. There is a correlation of the individual delta range measurement with T_u, and we have found a simple quadratic correction of the delta range for T_u variation. Using the individual delta range estimates from calibration mode 1 step 5 together with the T_u data for cycles 10-87, we have used simple least-squares fitting to find that an additive delta range adjustment Da in millimeters is approximately

$$Da = -1.817*(T_u - 25.5) - 0.073*(T_u - 25.5)**2,$$

where T_u is in degrees C and Da is in millimeters.

The temperature correction Da both smooths out the trend of cycle averages of combined delta range and reduces the standard deviations of the cycle averages. From our instrument science interests, it is appropriate to examine and to report the combined range bias changes after correction for the T_u.

For the results reported in Table 3-1, very slightly different edit criteria were used on the calibration mode data than in the October 1994 article, and the data fit for temperature effects now includes 13 more data cycles than the October 1994 results. The edit criteria and the temperature fit have not been changed since February 1996. The result of the different fit is that the combined delta range values here may differ from those in the October 1994 article, typically by 0.05 mm. The delta range results reported here may be valid at levels approaching a millimeter, but we think it is unrealistic to worry about differences at the level of tenths of a millimeter.

The first column in Table 3-1 is the TOPEX data cycle and the second column indicates the number of individual calibrations in each cycle average. The dRc_av_N is the cycle average of the combined delta range in millimeters, with NO correction for temperature, and the standard deviation estimate of the individual combined delta range (with no temperature correction) is dRc_sd_N. For the temperature-corrected combined delta range, the corresponding cycle averages and standard deviations are designated dRc_av_T and dRc_sd_T. The cycle average for UCFM temperature in degrees centigrade is T_u_av, and the individual calibration standard deviation for this temperature is T_u_sd. Notice that the third and fourth columns of Table 3-1, the dRc_av_N and dRc_sd_N, have not been reported in earlier versions of this update work such as the October 1994 article.

Table 3-1 TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
001	15	+2.795	1.691	+2.003	0.645	25.086	0.834
002	18	+1.867	0.644	+1.747	0.725	25.488	0.166
003	18	+2.527	1.191	+1.792	1.085	25.143	0.239
004	18	+1.811	0.929	+1.731	0.827	25.507	0.335
005	20	+1.947	0.808	+1.611	0.680	25.368	0.207
006	20	+1.792	0.975	+2.305	0.578	25.826	0.433
007	14	+1.602	0.178	+2.104	0.625	25.823	0.331
008	18	+1.799	0.194	+1.534	0.411	25.408	0.149
009	17	+1.751	0.661	+1.437	0.524	25.378	0.282
010	20	+1.594	0.253	+1.780	0.618	25.651	0.376
011	20	+1.342	0.500	+2.350	0.481	26.092	0.316
012	19	+1.645	0.757	+1.978	0.614	25.732	0.332
013	15	+1.622	0.236	+1.475	0.285	25.473	0.113
014	17	+1.941	0.532	+1.181	0.592	25.129	0.227

Table 3-1 TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
015	19	+1.985	0.474	+1.288	0.702	25.163	0.328
016	20	+2.060	0.461	+1.772	0.511	25.393	0.266
017	21	+1.723	0.319	+2.023	0.393	25.715	0.299
018	18	+1.484	0.223	+1.867	0.394	25.761	0.202
019	16	+1.615	0.151	+1.039	0.359	25.234	0.163
021	20	+2.047	0.149	+1.713	0.336	25.368	0.236
022	20	+1.672	0.205	+1.657	0.562	25.544	0.278
023	19	+1.354	0.355	+1.505	0.341	25.635	0.246
024	21	+0.624	0.289	+1.229	0.349	25.881	0.191
025	20	+0.553	0.545	+1.454	0.439	26.031	0.462
026	19	+1.517	0.155	+1.080	0.260	25.313	0.153
027	20	+1.517	0.131	+1.019	0.287	25.278	0.165
028	20	+1.131	0.217	+1.074	0.307	25.523	0.201
029	20	+0.614	0.255	+1.040	0.486	25.784	0.241
030	18	+0.924	0.372	+0.726	0.337	25.443	0.267
032	18	+1.727	0.397	+0.882	0.209	25.079	0.291
033	17	+0.805	0.869	+0.561	0.337	25.409	0.540
034	20	+0.023	0.152	-0.126	0.491	25.471	0.242
035	18	-0.490	0.606	-0.061	0.431	25.784	0.295
036	20	-0.777	0.667	-0.181	0.461	25.876	0.189
037	18	+0.283	0.482	+0.049	0.526	25.426	0.129
038	19	+0.734	0.322	+0.622	0.250	25.491	0.268
039	20	+0.834	0.406	+0.629	0.315	25.440	0.260
040	21	+0.690	0.419	+0.607	0.242	25.507	0.246
042	20	-0.609	0.536	+0.224	0.422	26.002	0.185
043	19	-0.081	0.240	+0.043	0.344	25.621	0.216
044	17	+0.152	0.227	-0.027	0.370	25.455	0.169
045	20	+0.170	0.223	+0.156	0.267	25.547	0.099
046	19	-0.316	0.655	+0.208	0.514	25.837	0.212
047	19	-1.348	0.334	-0.496	0.422	26.012	0.168

Table 3-1 TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
048	19	-0.148	0.588	+0.136	0.375	25.707	0.268
049	18	-0.165	0.421	-0.318	0.434	25.468	0.266
050	19	+1.349	0.603	-0.001	0.309	24.789	0.255
051	20	-0.076	0.723	-0.183	0.427	25.493	0.294
052	20	-0.183	0.270	-0.398	0.344	25.436	0.122
053	20	-1.823	0.666	-1.079	0.389	25.954	0.254
054	21	-0.810	0.702	-0.609	0.310	25.661	0.269
056	20	-0.435	0.715	-0.561	0.697	25.483	0.269
057	20	-1.059	0.418	-0.691	0.448	25.752	0.285
058	20	-0.957	0.323	-1.188	0.293	25.427	0.167
059	20	-2.053	0.580	-1.487	0.450	25.860	0.194
060	20	-2.299	0.543	-1.664	0.346	25.895	0.288
061	19	-1.569	0.236	-1.709	0.307	25.477	0.155
062	20	-1.455	0.157	-1.837	0.282	25.344	0.128
063	20	-1.392	0.158	-1.864	0.294	25.293	0.124
064	21	-2.245	0.554	-1.866	0.469	25.758	0.274
066	20	-1.488	0.154	-1.910	0.221	25.321	0.131
067	19	-1.843	0.400	-2.031	0.349	25.449	0.245
068	20	-0.302	0.639	-1.938	0.390	24.621	0.261
069	20	-2.039	0.472	-1.956	0.324	25.598	0.260
070	20	-2.554	1.102	-2.351	0.458	25.657	0.479
071	20	-3.780	0.575	-3.011	0.456	25.968	0.197
072	20	-4.598	1.804	-3.667	1.111	26.046	0.491
073	19	-2.411	0.518	-2.456	0.281	25.528	0.236
074	20	-2.742	0.410	-2.917	0.276	25.458	0.138
075	20	-3.112	0.595	-2.958	0.292	25.637	0.239
076	19	-2.598	0.483	-2.794	0.390	25.446	0.157
077	19	-3.883	0.374	-3.314	0.407	25.862	0.192
078	20	-3.715	0.444	-3.132	0.632	25.867	0.299
080	19	-3.059	0.350	-2.809	0.308	25.690	0.157

Table 3-1 TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
081	20	-3.526	0.300	-3.114	0.340	25.778	0.125
082	20	-5.491	1.251	-4.348	0.960	26.163	0.283
083	20	-4.814	0.724	-3.974	0.844	26.006	0.198
084	20	-3.976	0.258	-4.118	0.322	25.476	0.137
085	20	-3.276	1.038	-3.712	0.418	25.304	0.512
086	20	-1.596	1.172	-2.628	0.637	24.970	0.384
087	20	-4.199	0.212	-3.843	0.433	25.746	0.282
088	21	-4.296	0.252	-3.827	0.502	25.808	0.216
089	20	-4.434	0.327	-3.561	0.493	26.023	0.194
090	20	-4.181	0.262	-3.921	0.625	25.691	0.393
092	20	-3.337	0.855	-2.838	0.681	25.824	0.202
093	20	-3.732	0.244	-3.631	0.540	25.608	0.236
094	20	-3.918	0.273	-3.481	0.422	25.791	0.205
095	20	-4.374	0.294	-3.650	0.486	25.945	0.143
096	19	-4.268	0.248	-4.079	0.502	25.656	0.240
098	19	-3.373	0.152	-3.689	0.297	25.379	0.142
099	20	-3.528	0.161	-3.660	0.408	25.481	0.176
100	19	-3.759	1.072	-3.452	0.572	25.714	0.468
101	20	-4.003	0.232	-3.706	0.551	25.714	0.265
102	20	-3.895	0.161	-4.137	0.408	25.420	0.217
104	20	-2.646	1.185	-3.306	0.504	25.177	0.545
105	20	-3.457	0.213	-3.126	0.497	25.732	0.276
106	20	-3.779	0.499	-3.170	0.592	25.882	0.229
107	20	-4.509	0.207	-3.579	0.481	26.053	0.244
108	19	-3.955	0.196	-3.961	0.352	25.551	0.177
109	19	-3.808	0.168	-3.531	0.415	25.704	0.240
110	20	-3.705	0.252	-3.311	0.296	25.769	0.152
111	20	-3.727	0.143	-3.807	0.260	25.511	0.149
112	20	-4.028	0.351	-3.418	0.255	25.884	0.173
113	20	-4.251	0.202	-3.275	0.277	26.078	0.174

Table 3-1 TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
115	17	-3.092	0.336	-2.734	0.321	25.748	0.167
116	20	-3.045	0.295	-2.779	0.391	25.699	0.127
117*	16	-3.191	0.299	-2.586	0.430	25.881	0.194
119	17	-5.211	1.013	-3.527	0.925	26.438	0.482
120	20	-4.668	0.454	-4.420	0.593	25.689	0.207
121	19	-3.735	0.675	-4.940	0.315	24.869	0.430
122	20	-4.013	0.622	-4.076	0.563	25.509	0.556
123**	13	-4.242	0.658	-4.225	0.524	25.559	0.348
124	20	-4.758	0.797	-3.166	1.176	26.394	0.359
125	21	-4.860	0.574	-3.307	0.712	26.376	0.280
127	19	-3.726	0.617	-2.929	0.385	25.981	0.315
128	20	-3.983	0.310	-3.239	0.384	25.954	0.279
129	20	-3.722	0.214	-3.439	0.352	25.708	0.206
130	20	-4.125	0.783	-3.060	0.693	26.123	0.279
131	20	-2.970	0.615	-2.191	0.512	25.973	0.243
132	19	-2.120	0.172	-2.254	0.321	25.481	0.122
133	20	-1.948	0.127	-2.096	0.296	25.473	0.129
134	20	-1.764	0.184	-2.089	0.323	25.375	0.118
135	20	-2.604	0.710	-2.016	0.347	25.870	0.297
136	20	-2.878	0.371	-2.320	0.344	25.856	0.194
137	21	-1.968	0.904	-2.072	0.465	25.490	0.456
139	20	+0.712	0.893	-0.705	0.404	24.746	0.391
140	20	-1.252	0.839	-1.133	0.388	25.615	0.360
141	20	-1.464	0.285	-1.528	0.380	25.519	0.186
142	20	-2.613	0.539	-1.793	0.411	25.994	0.235
143	19	-2.626	0.558	-1.854	0.392	25.967	0.318
144	18	-1.490	0.210	-1.795	0.364	25.386	0.159
145	21	-1.980	0.377	-1.535	0.358	25.793	0.288
146	20	-1.569	0.408	-1.827	0.293	25.411	0.218
147	19	-1.736	0.341	-1.645	0.230	25.604	0.136

Table 3-1 TOPEX Range Bias Changes Based on Calibration Mode 1 Step 5 (Continued)

Cyc	Count	dR_av_N	dR_sd_N	dR_av_T	dR_sd_T	Tu_av	Tu_sd
148	18	-3.065	0.336	-1.783	0.538	26.235	0.315
149	20	-2.741	0.630	-2.075	0.393	25.910	0.369
151	20	-1.701	1.027	-1.119	0.675	25.868	0.249
152	20	-1.737	0.208	-1.379	0.324	25.749	0.146
153	20	-2.548	0.751	-1.350	0.471	26.191	0.322
154	20	-2.961	0.288	-1.738	0.292	26.206	0.234
155	20	-2.214	0.683	-1.804	0.431	25.769	0.480
156	19	-1.607	0.511	-1.587	0.281	25.562	0.312
157	21	+0.909	0.954	-0.552	0.876	24.721	0.356
158	20	-1.144	0.562	-0.699	0.510	25.794	0.262
159	20	-1.162	0.776	-0.691	0.400	25.803	0.456

* Late part of cycle 117 and most of cycle 118 lost because of TOPEX SafeHold / PowerOff condition. Power was restored to the altimeter late in cycle 118, but remaining cycle 118 calibrations were removed from our analysis data set to allow altimeter temperatures to stabilize.

** SafeHold / PowerOff during cycle 123; then both calibrations on 1996 day 023 were edited out of the altimeter data to allow altimeter temperatures to stabilize after power was restored.

These delta ranges are plotted in Figure 3-1 and Figure 3-2, where Figure 3-1 contains range corrections which have not been modified for the effects of temperature, and Figure 3-2 values have been temperature-corrected.

3.2 AGC/Sigma Naught

The correction to AGC (automatic gain control) and to Sigma Naught (or sigma0) have been derived from analyses of the data cycle-averages of global over-ocean sigma0. The cycle-average sigma0 values would, if not corrected, show a continual decrease since launch, with a Ku-band decrease of approximately 1.5 dB and C-band decrease of approximately 1.2 dB from launch to December 1996. The TOPEX ground processing includes an AGC Calibration Table (to be referred to as the AGC Cal Table) whose entries are additive corrections to the Ku- and C-Band AGC values. Since the TOPEX sigma0 estimates vary directly as AGC, the AGC Cal Table can also be viewed as a correction table for the altimeter's sigma0 estimates. Early in 1994 we decided that the uncorrected sigma0 cycle averages provided a better basis for correction than the measurement of AGC in both Calibration Modes 1 and 2, and the uncorrected sigma0 trends continue to be used in producing the AGC Cal Table entries.

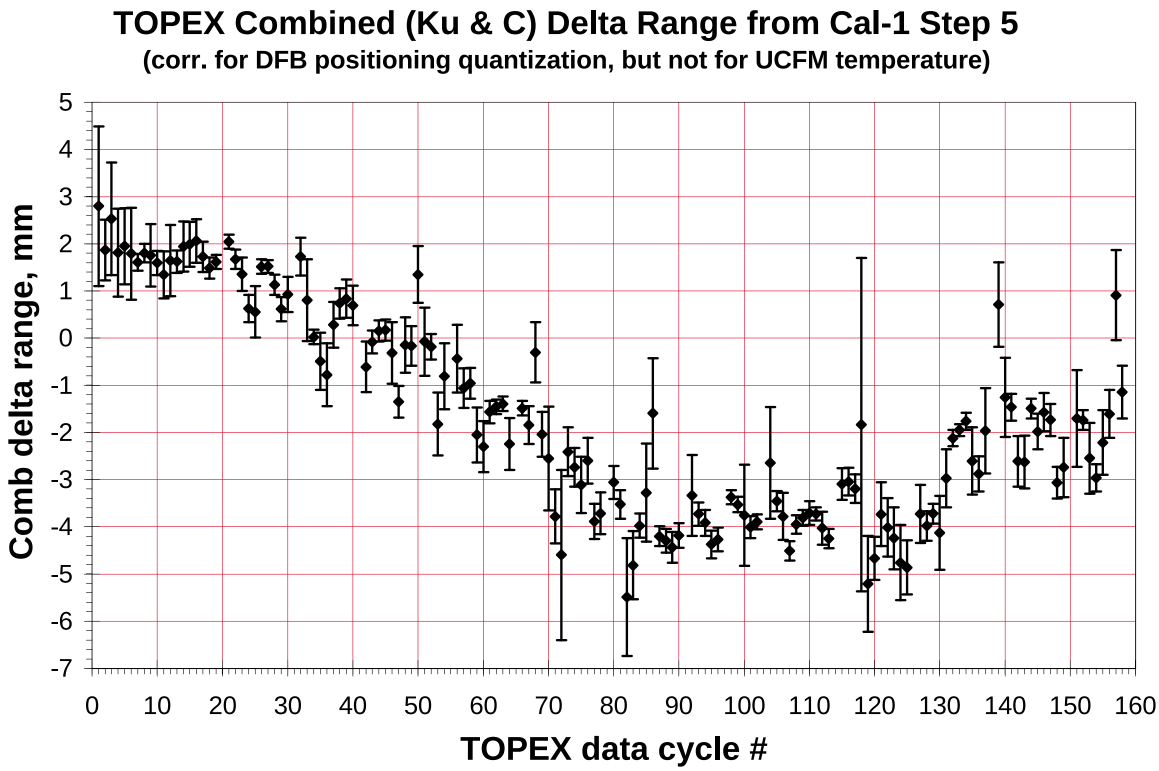


Figure 3-1 Range Corrections not Modified for the Effects of Temperature

The starting point for all our sigma0 trend studies is the WFF science database of 1-minute averages of TOPEX GDR data. Cycle-average sigma0 values are obtained from this database with the following modifications:

- The AGC Cal Table corrections that had been entered into the GDR processing by the TOPEX/Poseidon Project were removed so that the long-term trends without corrections could be plotted (i.e., the "uncorrected" sigma0 values could be plotted vs. time).
- The sigma0 values were then normalized to a standard significant waveheight (SWH) value of 2.85 m using an empirical adjustment of approximately 0.4 dB per meter of SWH. This empirical adjustment was derived from TOPEX data in year 1995 and earlier. The SWH adjustment does not make a major contribution to the time trend analysis, and the same overall time trends are seen in uncorrected sigma0 data for which no SWH adjustment has been made.
- To plot both the sigma0 trend and the Cal Mode AGC trends on the same figure, a constant bias of 11.32 dB was subtracted from the Ku-band sigma0 values and 15.30 dB was subtracted from the C-band sigma0 values.

Figure 3-3 "TOPEX Ku Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0" on page 3-10 summarizes the uncorrected sigma0 time trends for the Ku-band altimeter, and Figure 3-4 "TOPEX C-Band Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0" on

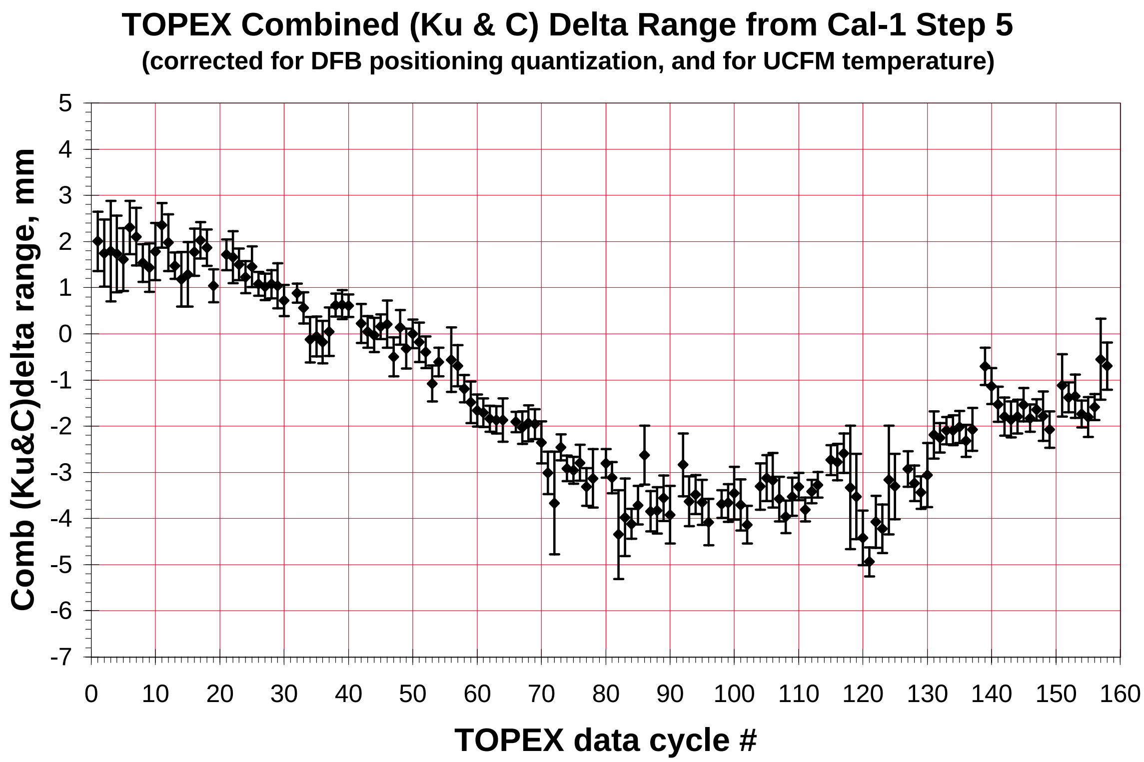


Figure 3-2 Range Corrections which have been Temperature-Corrected

page 3-11 summarizes the uncorrected sigma0 time trends for the C-band altimeter. Also shown in Figure 3-3 and Figure 3-4 are the relative change in the AGC measured from Cal Mode 1 Step 5 and Cal Mode 2. It can be seen that the Cal Mode 1 AGC time trend has slightly different behavior than the uncorrected cycle-average sigma0. The figures also show the behavior of the Ku- and C-Band Transmit Power monitors, also in relative dB.

The TOPEX uncorrected sigma naught time behavior was treated as linear with time in various analysis work done through the end of 1995. With the additional 1996 data, a nonlinear behavior has appeared, and the uncorrected sigma0 drifts can no longer be treated as a simple linear functions of time as can be seen in Figure 3-3 and Figure 3-4. In these two figures the (negative, shifted) Cal Table values are also plotted. The Figure 3-3 and Figure 3-4 Cal Table values are not those actually used in the GDR processing for cycles 001-109, but are the results of an analysis in September 1995 which treated time trends as purely linear and changed the Cal Table values at a 0.03 dB quantization. The Cal Table values from cycle 110 upward, in Figure 3-3 and Figure 3-4, are those actually used in the GDR processing.

There have been several adjustments to the AGC Cal Table in 1996 in attempts to keep up with the uncorrected sigma0's departure from being a purely linear function of time (or, equivalently, of cycle number). Each time that the AGC Cal Table contents are changed in the TOPEX ground data processing at JPL, there are at least these three items created:

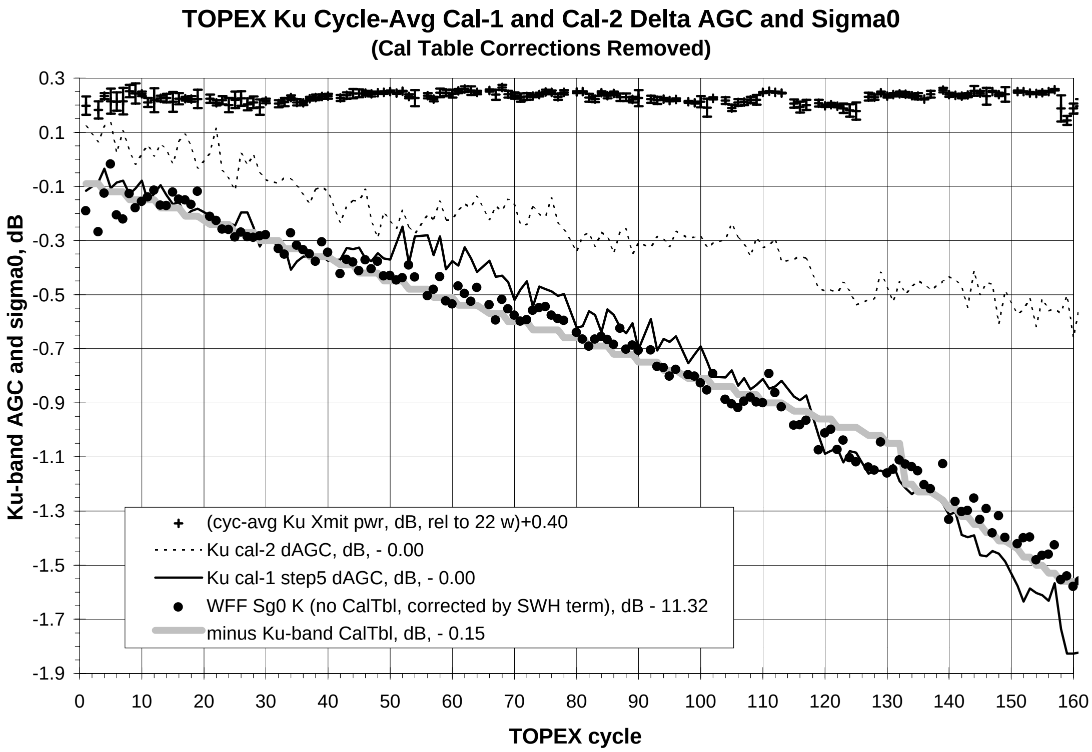


Figure 3-3 TOPEX Ku Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0

- The MOS Change Request Form (the MCR) has an origination date, describes the change to be made and the desired operational date for the change, and has the date when the MCR was approved (by a change control board at JPL).
- The Parameter File is the text file to be actually used in the data processing; this file contains the AGC Cal Table values for each cycle.
- The File Release Form contains the Parameter File creation date, the release approval date, and the date at which file execution is to begin.

We have obtained copies of all the sigma0-related MCRs and File Release Forms, and have summarized the information from these in Table 3-2 "MCR and File Release Data". Columns 1 to 4 of this Table are transcribed from the MCR Forms, columns 5 to 7 from the File Release Forms, and column 8 contains a brief indication of what change the MCR made and why.

Even with the information summarized in Table 3-2 "MCR and File Release Data" on page 3-11, it is not possible to completely and unambiguously determine what MCR applied to each TOPEX cycle.

This is in part because some of the File Release Form's dates at which file execution was to begin specified dates before the Parameter File's creation date, to accommodate cycle reprocessing. Also, the creation date of the Parameter File was only the date at which the information was entered into a file at some off-line terminal, and

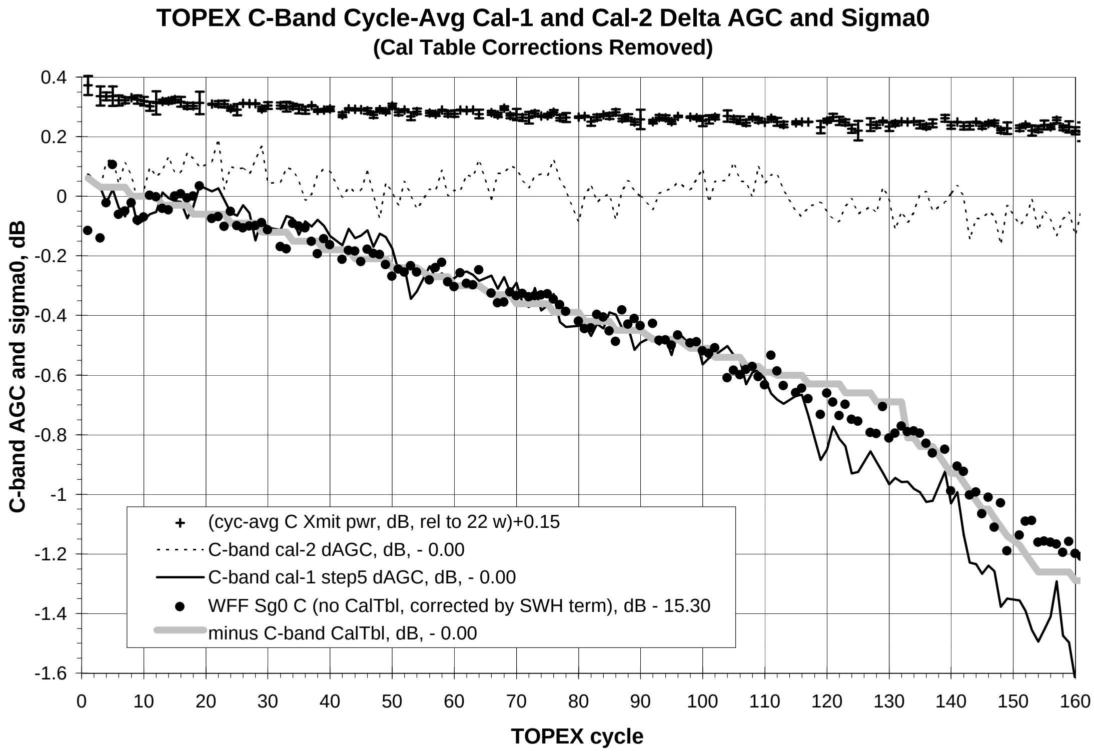


Figure 3-4 TOPEX C-Band Cycle-Avg Cal-1 and Cal-2 Delta AGC and Sigma0

was not the date at which the Parameter File was actually installed in the data processing. The TOPEX processing does enter the processing software version number in the GDR file header, and it is unfortunate that no similar provision had been made for entering the Cal Table version number into the GDR header. However, Frank Salamone at JPL was able to provide us with dates at which the IGDRs were created for Pass 001 and Pass 013 of each data cycle, and with this additional information the MCR ambiguity can be resolved. Column 9 of Table 3-2 lists, to our current best estimate, the TOPEX cycles governed by each MCR.

Table 3-2 MCR and File Release Data

(from MCR Form)				*(from File Release Form)*				
(1) MCR #	(2) MCR Orig. Date	(3) Desired Operational Date	(4) Comments on MCR Form	(5) File Creation Date	(6) Release Approval Date	(7) File Execution to Begin (cycle begin)	(8) Comments on MCR actions and reasons	(9) Cycle Under This MCR
432	93/05/11 1993-131	93/05/12		93/05/12 ?	93/05/12 ?	start of mission	At start of mission, had zeros in both Ku and C AGC table	001-047

Table 3-2 MCR and File Release Data

(from MCR Form)				*(from File Release Form)*				
(1) MCR #	(2) MCR Orig. Date	(3) Desired Operational Date	(4) Comments on MCR Form	(5) File Creation Date	(6) Release Approval Date	(7) File Execution to Begin (cycle begin)	(8) Comments on MCR actions and reasons	(9) Cycle Under This MCR
492	94/01/10 1994-010	cycle 048 94/01/12	reprocess cycle 48 IGDRs, process all from 48 on using this file	94/01/10 T18:05:00	94/01/12	94/01/02 1994-002 T04:28:00 *(cycle 048)*	First non-zero entries. Start applying to IGDRs at cycle 048, and add steps backward at cycles 015, 021, and 029.	048- 055
501	94/03/30 1994-089	cycle 056 94/03/31	change to start at cycle 56 IGDRs	94/03/30 T23:00:00	94/03/31	94/03/22 1994-081 T12:17:00 *(cycle 056)*	Add another step starting at cycle 056, keep rest of values same as MCR 492.	056- 075
529	94/10/18 1994-291	cycle 076 94/10/19	use for cycle 76 IGDRs	94/10/17 T14:00:00	94/10/19	94/10/06 1994-279 T19:47:00 *(cycle 076)*	Start at cycle 076, and replace earlier cycle values by linear ramp at 0.05 dB steps.	076- 081
539	95/01/05 1995-005	95/01/04	reprocess cycle 80-83, use for 84 onward	95/01/04 T19:40:00	95/01/04	94/12/05 1994-339 T07:38:00 *(cycle 082)*	Start at cycle 082. Extend linear ramp of MCR 529, predicting next cycles correction.	082- 092
548	95/03/24 1995-083	cycle 93 95/03/29	use for cycle 93 IGDRs	95/03/29 T21:20:00	95/03/29	95/01/13 1995-013 T23:32:43 *(cycle 086)*	Start at 093. Use linear prediction for next cycles, earlier values same as MCR 539. Note that begin exec. date is earlier than file creation, for reprocessing.	093- 102
562	95/07/10 1995-191	95/07/12	use for cycle 103	95/07/10 T20:52:00	95/07/11	95/07/01 1995-182 T13:07:39 *(cycle 103)*	Start at cycle 103 (a SSALT cycle). Extend linear ramp of MCR 548, predicting next cycles correction.	103- 109

Table 3-2 MCR and File Release Data

(from MCR Form)				*(from File Release Form)*				
(1) MCR #	(2) MCR Orig. Date	(3) Desired Operational Date	(4) Comments on MCR Form	(5) File Creation Date	(6) Release Approval Date	(7) File Execution to Begin (cycle begin)	(8) Comments on MCR actions and reasons	(9) Cycle Under This MCR
530	95/09/13 1995-256	95/09/15	use for cycle 110	95/09/14 T18:10:00	95/09/15	95/09/08 1995-251 T22:57:19 *(cycle 110)*	Start at cycle 110. Refitted linear trend, extend backward, now using 0.03 dB steps.	110-121
585	95/12/13 1995-347	cycle 122 96/01/03	use for cycle 122	96/01/04 T23:21:45	96/01/04	96/01/05 1996-005 T22:39:35 *(cycle 122)*	Start at cycle 122. Linear trend from MCR 530 was extended forward.	122-132
598	96/05/01 1996-122	cycle 133 96/05/01	hold cycle 133 IGDR production until update is made	96/05/01 T21:21:10	96/05/01	96/04/24 1996-115 T00:23:25 *(cycle 133)*	At 133 put in a jump and a slope change to adapt to nonlinear time trend. Use MCR 585 values for cycles 001-132.	133-142
608	96/07/16 1996-198	cycle 143		96/07/22 T17:30:30	96/07/24	96/08/01 1996-214 T04:08:38 *(cycle 143)*	Extend forward the trend started in MCR 598.	143-147
614	96/09/20 1996-264	96/09/25	use for cycle 148	96/09/25 T16:30:00	96/09/25	96/09/19 1996-263 T18:01:15 *(cycle 148)*	At 148 put different jump and slope. Use MCR 608 values for cycles 001-147.	148-149
618	96/10/01 1996-275	96/10/02	use as part of reprocessing from cycle 133	96/10/07 T17:31:00	96/10/07	96/09/19 1996-263 T18:01:15 *(cycle 148)*	Cycle 150 was SSALT. Execution date earlier than creation date for reprocessed 133-153 (#). Values same as MCR 614 for cycles 001-086, then different (line segment fit).	133-153# 151-153
629	96/12/04 1996-339	cycle 156 96/12/11	change before processing cycle 156	96/12/09 T22:44:00	96/12/11	96/11/18 1996-323 T05:52:26 *(cycle 154)*	Keep Ku values of MCR 618, but freeze C-band value starting at cycle 154.	154-159

Table 3-2 MCR and File Release Data

(from MCR Form)				*(from File Release Form)*				
(1) MCR #	(2) MCR Orig. Date	(3) Desired Operational Date	(4) Comments on MCR Form	(5) File Creation Date	(6) Release Approval Date	(7) File Execution to Begin (cycle begin)	(8) Comments on MCR actions and reasons	(9) Cycle Under This MCR
630	97/01/20 1997-020	97/01/22	use for cycle 160	97/01/22 T16:44:00	97/01/22	97/01/16 1997-016 T17:43:34 *(cycle 160)*	Use new line seg fit, start with cycle 160. Values same as MCR 629 until cycle 156.	160--

The main problem in producing correct AGC Cal Table values is the difficulty in projecting a noisy data series into the future. Once the data are in, it is possible to make a better guess at what the AGC Cal Table values should have been, and Figure 3-5 "Ku Sigma0 (SWH-Corrected, Cal Table Removed)" on page 3-14 and Figure 3-6 "C

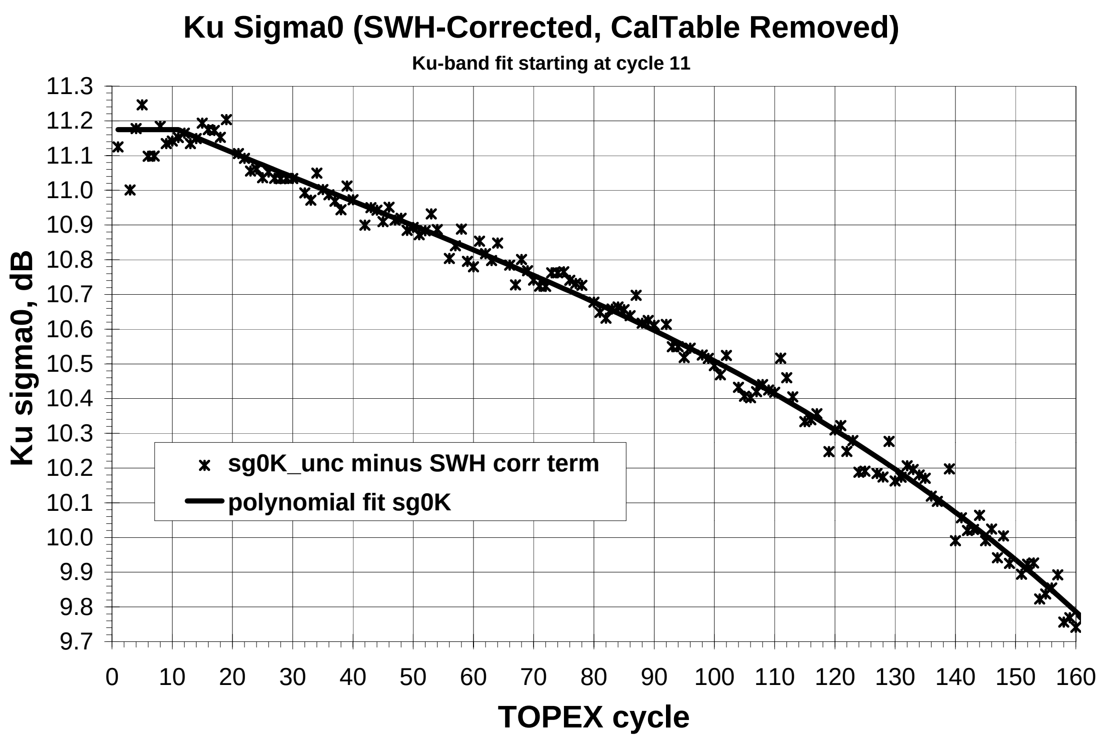


Figure 3-5 Ku Sigma0 (SWH-Corrected, Cal Table Removed)

Sigma0 (SWH-Corrected, Cal Table Removed)" on page 3-15 show this for Ku- and C-Band uncorrected SWH-adjusted sigma0 values, respectively. In these Figures, the

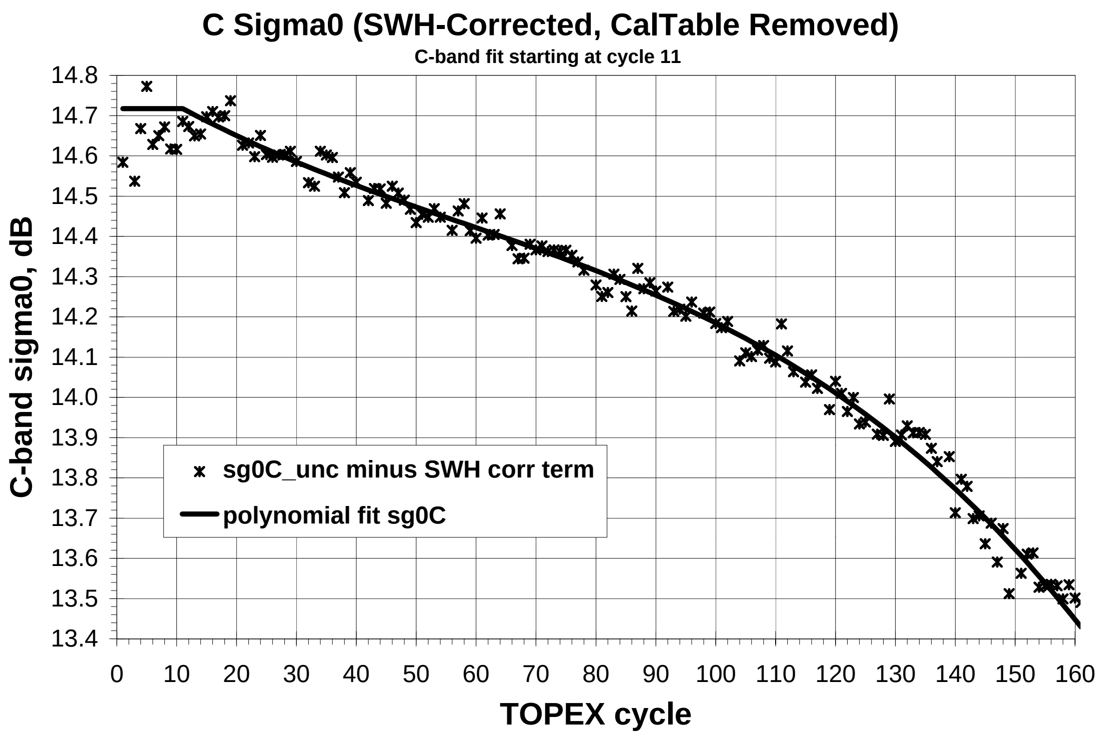


Figure 3-6 C Sigma0 (SWH-Corrected, Cal Table Removed)

“better guess” is a cubic polynomial function fitted to the data from cycles 011 through 162.

Table 3-3 "GDR Cal Table for Original Data Processing" on page 3-17 summarizes for TOPEX cycles 001 to 162 the applicable MCR (column 4), the AGC Cal Table values actually used in GDR production (columns 5 and 6 for Ku- and C-Band, respectively), and the Cal Table values from the polynomial fit (columns 7 and 8, for Ku- and C-Band). Notice that the GDRs for cycles 133 to 149 were reprocessed and re-released, and that Table 3-4 "GDR Cal Table for Reprocessing Cycles 133-149" on page 3-23 provides the information for the reprocessed cycles. These AGC and Sigma0 calibration tables are updated regularly on our WFF/TOPEX Web site, at http://osb3.wff.nasa.gov/topex/docs/Sigma0Cal.html.

Figure 3-7 "TOPEX Ku-Band AGC Cal Table Values at each Cycle" on page 3-16 and Figure 3-8 "TOPEX C-Band AGC Cal Table Values at each Cycle" on page 3-16 compare the AGC Cal Table values actually used in GDR production with the Cal Table values from the polynomial fit. A data user wanting to improve TOPEX sigma0 estimates should subtract the Table 3-3 "GDR Cal Table for Original Data Processing" on page 3-17 (or Table 3-4 "GDR Cal Table for Reprocessing Cycles 133-149" on page 3-23) column 5 value from the GDR Ku-Band sigma0, and then add the column 7 value

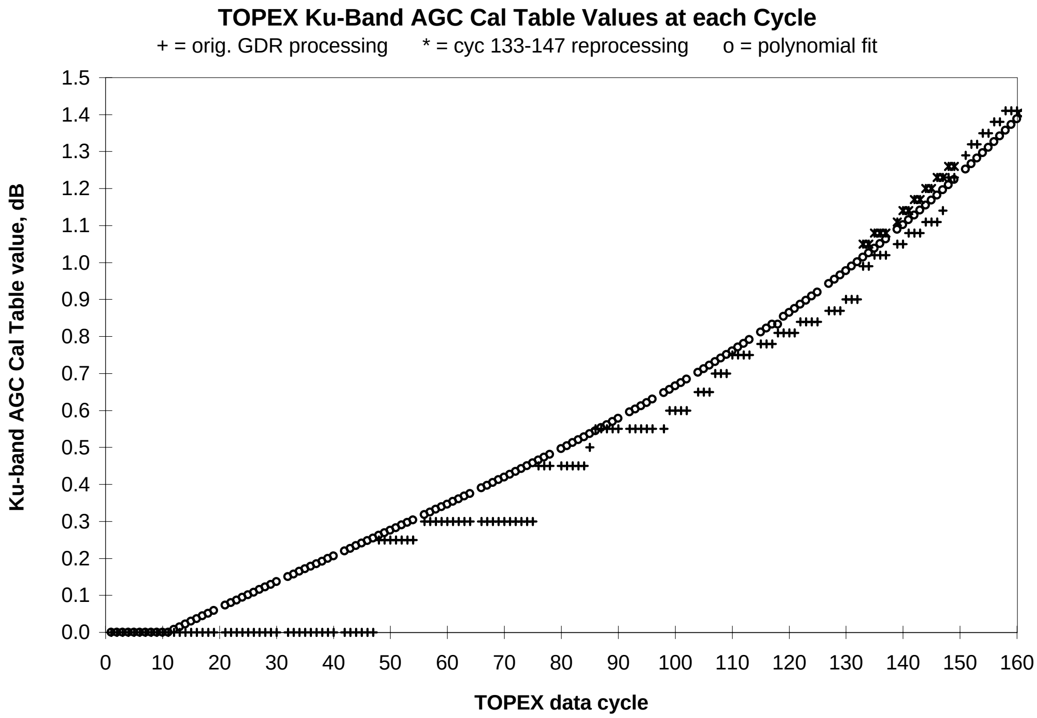


Figure 3-7 TOPEX Ku-Band AGC Cal Table Values at each Cycle

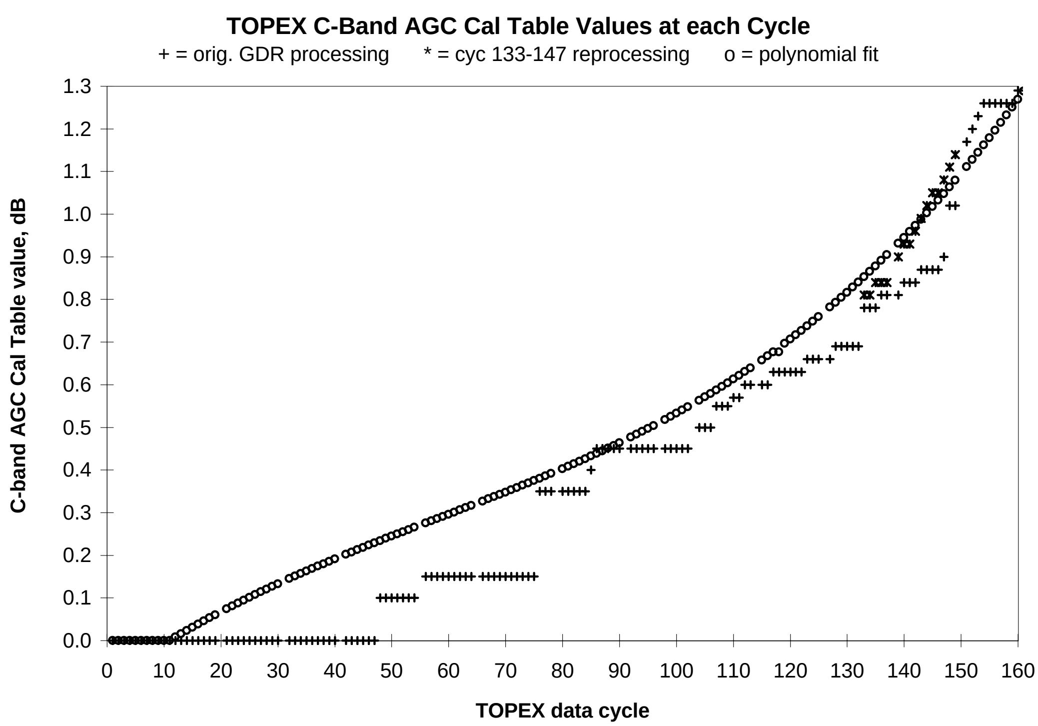


Figure 3-8 TOPEX C-Band AGC Cal Table Values at each Cycle

to this result. For C-Band, one would subtract the Table 3-3 or Table 3-4) column 6 value from the GDR C-Band sigma0 and then add the column 8 value to this result.

Table 3-3 GDR Cal Table for Original Data Processing

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
001	1992-267	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
002	1992-277	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
003	1992-286	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
004	1992-296	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
005	1992-306	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
006	1992-316	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
007	1992-326	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
008	1992-336	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
009	1992-346	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
010	1992-356	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
011	1992-366	mixed	MCR432	+0.00	+0.00	+0.000	+0.000
012	1993-010	mixed	MCR432	+0.00	+0.00	+0.007	+0.008
013	1993-020	mixed	MCR432	+0.00	+0.00	+0.015	+0.016
014	1993-030	mixed	MCR432	+0.00	+0.00	+0.022	+0.023
015	1993-039	mixed	MCR432	+0.00	+0.00	+0.030	+0.031
016	1993-049	mixed	MCR432	+0.00	+0.00	+0.037	+0.039
017	1993-059	NRA	MCR432	+0.00	+0.00	+0.044	+0.046
018	1993-069	NRA	MCR432	+0.00	+0.00	+0.051	+0.053
019	1993-079	NRA	MCR432	+0.00	+0.00	+0.059	+0.060
020	1993-089	SSALT					
021	1993-099	NRA	MCR432	+0.00	+0.00	+0.073	+0.074
022	1993-109	NRA	MCR432	+0.00	+0.00	+0.080	+0.081
023	1993-119	NRA	MCR432	+0.00	+0.00	+0.087	+0.088
024	1993-129	NRA	MCR432	+0.00	+0.00	+0.094	+0.095

Table 3-3 GDR Cal Table for Original Data Processing (Continued)

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
025	1993-139	NRA	MCR432	+0.00	+0.00	+0.101	+0.101
026	1993-149	NRA	MCR432	+0.00	+0.00	+0.108	+0.108
027	1993-158	NRA	MCR432	+0.00	+0.00	+0.115	+0.114
028	1993-168	NRA	MCR432	+0.00	+0.00	+0.123	+0.120
029	1993-178	NRA	MCR432	+0.00	+0.00	+0.130	+0.127
030	1993-188	NRA	MCR432	+0.00	+0.00	+0.137	+0.133
031	1993-198	SSALT					
032	1993-208	NRA	MCR432	+0.00	+0.00	+0.151	+0.145
033	1993-218	NRA	MCR432	+0.00	+0.00	+0.157	+0.151
034	1993-228	NRA	MCR432	+0.00	+0.00	+0.164	+0.157
035	1993-238	NRA	MCR432	+0.00	+0.00	+0.171	+0.163
036	1993-248	NRA	MCR432	+0.00	+0.00	+0.178	+0.169
037	1993-258	NRA	MCR432	+0.00	+0.00	+0.185	+0.174
038	1993-268	NRA	MCR432	+0.00	+0.00	+0.192	+0.180
039	1993-277	NRA	MCR432	+0.00	+0.00	+0.199	+0.186
040	1993-287	NRA	MCR432	+0.00	+0.00	+0.206	+0.191
041	1993-297	SSALT					
042	1993-307	NRA	MCR432	+0.00	+0.00	+0.220	+0.202
043	1993-317	NRA	MCR432	+0.00	+0.00	+0.227	+0.208
044	1993-327	NRA	MCR432	+0.00	+0.00	+0.234	+0.213
045	1993-337	NRA	MCR432	+0.00	+0.00	+0.241	+0.218
046	1993-347	NRA	MCR432	+0.00	+0.00	+0.248	+0.224
047	1993-357	NRA	MCR432	+0.00	+0.00	+0.255	+0.229
048	1994-002	NRA	MCR492	+0.25	+0.10	+0.262	+0.234
049	1994-012	NRA	MCR492	+0.25	+0.10	+0.269	+0.239
050	1994-022	NRA	MCR492	+0.25	+0.10	+0.276	+0.245

Table 3-3 GDR Cal Table for Original Data Processing (Continued)

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
051	1994-031	NRA	MCR492	+0.25	+0.10	+0.283	+0.250
052	1994-041	NRA	MCR492	+0.25	+0.10	+0.290	+0.255
053	1994-051	NRA	MCR492	+0.25	+0.10	+0.297	+0.260
054	1994-061	NRA	MCR492	+0.25	+0.10	+0.304	+0.265
055	1994-071	SSALT					
056	1994-081	NRA	MCR501	+0.30	+0.15	+0.318	+0.276
057	1994-091	NRA	MCR501	+0.30	+0.15	+0.325	+0.281
058	1994-101	NRA	MCR501	+0.30	+0.15	+0.332	+0.286
059	1994-111	NRA	MCR501	+0.30	+0.15	+0.339	+0.291
060	1994-121	NRA	MCR501	+0.30	+0.15	+0.346	+0.296
061	1994-131	NRA	MCR501	+0.30	+0.15	+0.354	+0.301
062	1994-141	NRA	MCR501	+0.30	+0.15	+0.361	+0.306
063	1994-150	NRA	MCR501	+0.30	+0.15	+0.368	+0.311
064	1994-160	NRA	MCR501	+0.30	+0.15	+0.375	+0.317
065	1994-170	SSALT					
066	1994-180	NRA	MCR501	+0.30	+0.15	+0.390	+0.327
067	1994-190	NRA	MCR501	+0.30	+0.15	+0.397	+0.332
068	1994-200	NRA	MCR501	+0.30	+0.15	+0.405	+0.337
069	1994-210	NRA	MCR501	+0.30	+0.15	+0.412	+0.343
070	1994-220	NRA	MCR501	+0.30	+0.15	+0.420	+0.348
071	1994-230	NRA	MCR501	+0.30	+0.15	+0.427	+0.353
072	1994-240	NRA	MCR501	+0.30	+0.15	+0.435	+0.359
073	1994-250	NRA	MCR501	+0.30	+0.15	+0.442	+0.364
074	1994-259	NRA	MCR501	+0.30	+0.15	+0.450	+0.369
075	1994-269	NRA	MCR501	+0.30	+0.15	+0.458	+0.375
076	1994-279	NRA	MCR529	+0.45	+0.35	+0.465	+0.380

Table 3-3 GDR Cal Table for Original Data Processing (Continued)

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
077	1994-289	NRA	MCR529	+0.45	+0.35	+0.473	+0.386
078	1994-299	NRA	MCR529	+0.45	+0.35	+0.481	+0.392
079	1994-309	SSALT					
080	1994-319	NRA	MCR529	+0.45	+0.35	+0.497	+0.403
081	1994-329	NRA	MCR529	+0.45	+0.35	+0.504	+0.409
082	1994-339	NRA	MCR539	+0.50	+0.40	+0.512	+0.415
083	1994-349	NRA	MCR539	+0.50	+0.40	+0.520	+0.420
084	1994-359	NRA	MCR539	+0.50	+0.40	+0.529	+0.426
085	1995-004	NRA	MCR539	+0.50	+0.40	+0.537	+0.432
086	1995-013	NRA	MCR539	+0.55	+0.45	+0.545	+0.439
087	1995-023	NRA	MCR539	+0.55	+0.45	+0.553	+0.445
088	1995-033	NRA	MCR539	+0.55	+0.45	+0.561	+0.451
089	1995-043	NRA	MCR539	+0.55	+0.45	+0.570	+0.457
090	1995-053	NRA	MCR539	+0.55	+0.45	+0.578	+0.464
091	1995-063	SSALT					
092	1995-073	NRA	MCR539	+0.55	+0.45	+0.595	+0.477
093	1995-083	NRA	MCR548	+0.55	+0.45	+0.604	+0.483
094	1995-093	NRA	MCR548	+0.55	+0.45	+0.613	+0.490
095	1995-103	NRA	MCR548	+0.55	+0.45	+0.621	+0.497
096	1995-113	NRA	MCR548	+0.55	+0.45	+0.630	+0.504
097	1995-123	SSALT					
098	1995-132	NRA	MCR548	+0.55	+0.45	+0.648	+0.518
099	1995-142	NRA	MCR548	+0.60	+0.45	+0.657	+0.525
100	1995-152	NRA	MCR548	+0.60	+0.45	+0.666	+0.533
101	1995-162	NRA	MCR548	+0.60	+0.45	+0.675	+0.540
102	1995-172	NRA	MCR548	+0.60	+0.45	+0.684	+0.548

Table 3-3 GDR Cal Table for Original Data Processing (Continued)

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
103	1995-182	SSALT					
104	1995-192	NRA	MCR562	+0.65	+0.50	+0.703	+0.563
105	1995-202	NRA	MCR562	+0.65	+0.50	+0.713	+0.571
106	1995-212	NRA	MCR562	+0.65	+0.50	+0.722	+0.579
107	1995-222	NRA	MCR562	+0.70	+0.55	+0.732	+0.588
108	1995-232	NRA	MCR562	+0.70	+0.55	+0.741	+0.596
109	1995-242	NRA	MCR562	+0.70	+0.55	+0.751	+0.604
110	1995-251	NRA	MCR530	+0.75	+0.57	+0.761	+0.613
111	1995-261	NRA	MCR530	+0.75	+0.57	+0.771	+0.622
112	1995-271	NRA	MCR530	+0.75	+0.60	+0.781	+0.630
113	1995-281	NRA	MCR530	+0.75	+0.60	+0.791	+0.639
114	1995-291	SSALT					
115	1995-301	NRA	MCR530	+0.78	+0.60	+0.812	+0.658
116	1995-311	NRA	MCR530	+0.78	+0.60	+0.822	+0.667
117	1995-321	NRA	MCR530	+0.78	+0.63	+0.833	+0.677
118	1995-331	NRA	MCR530	+0.81	+0.63	+0.833	+0.677
119	1995-341	NRA	MCR530	+0.81	+0.63	+0.854	+0.697
120	1995-351	NRA	MCR530	+0.81	+0.63	+0.865	+0.707
121	1995-361	NRA	MCR530	+0.81	+0.63	+0.875	+0.717
122	1996-005	NRA	MCR585	+0.84	+0.63	+0.886	+0.727
123	1996-015	NRA	MCR585	+0.84	+0.66	+0.898	+0.738
124	1996-025	NRA	MCR585	+0.84	+0.66	+0.909	+0.748
125	1996-035	NRA	MCR585	+0.84	+0.66	+0.920	+0.759
126	1996-045	SSALT					
127	1996-055	NRA	MCR585	+0.87	+0.66	+0.943	+0.782
128	1996-065	NRA	MCR585	+0.87	+0.69	+0.954	+0.793

Table 3-3 GDR Cal Table for Original Data Processing (Continued)

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
129	1996-075	NRA	MCR585	+0.87	+0.69	+0.966	+0.805
130	1996-085	NRA	MCR585	+0.90	+0.69	+0.978	+0.816
131	1996-095	NRA	MCR585	+0.90	+0.69	+0.990	+0.828
132	1996-105	NRA	MCR585	+0.90	+0.69	+1.002	+0.841
133	1996-115	NRA	MCR598	+0.99	+0.78	+1.014	+0.853
134	1996-124	NRA	MCR598	+0.99	+0.78	+1.026	+0.866
135	1996-134	NRA	MCR598	+1.02	+0.78	+1.038	+0.878
136	1996-144	NRA	MCR598	+1.02	+0.81	+1.051	+0.891
137	1996-154	NRA	MCR598	+1.02	+0.81	+1.064	+0.904
138	1996-164	SSALT					
139	1996-174	NRA	MCR598	+1.05	+0.81	+1.089	+0.931
140	1996-184	NRA	MCR598	+1.05	+0.84	+1.102	+0.945
141	1996-194	NRA	MCR598	+1.08	+0.84	+1.115	+0.959
142	1996-204	NRA	MCR598	+1.08	+0.84	+1.128	+0.973
143	1996-214	NRA	MCR608	+1.08	+0.87	+1.142	+0.988
144	1996-224	NRA	MCR608	+1.11	+0.87	+1.155	+1.003
145	1996-234	NRA	MCR608	+1.11	+0.87	+1.169	+1.017
146	1996-243	NRA	MCR608	+1.11	+0.87	+1.182	+1.033
147	1996-253	NRA	MCR608	+1.14	+0.90	+1.196	+1.048
148	1996-263	NRA	MCR614	+1.23	+1.02	+1.210	+1.063
149	1996-273	NRA	MCR614	+1.23	+1.02	+1.224	+1.079
150	1996-283	SSALT					
151	1996-293	NRA	MCR618	+1.29	+1.17	+1.253	+1.112
152	1996-303	NRA	MCR618	+1.32	+1.20	+1.267	+1.128
153	1996-313	NRA	MCR618	+1.32	+1.23	+1.282	+1.145
154	1996-323	NRA	MCR629	+1.35	+1.26	+1.296	+1.162

Table 3-3 GDR Cal Table for Original Data Processing (Continued)

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
155	1996-333	NRA	MCR629	+1.35	+1.26	+1.311	+1.179
156	1996-343	NRA	MCR629	+1.38	+1.26	+1.326	+1.197
157	1996-352	NRA	MCR629	+1.38	+1.26	+1.342	+1.215
158	1996-362	NRA	MCR629	+1.41	+1.26	+1.357	+1.233
159	1997-006	NRA	MCR629	+1.41	+1.26	+1.372	+1.251
160	1997-016	NRA	MCR630	+1.41	+1.29	+1.388	+1.269
161	1997-026	NRA	MCR630	+1.41	+1.29	+1.404	+1.288
162	1997-036	SSALT					

Table 3-4 GDR Cal Table for Reprocessing Cycles 133-149

(1) Data Cycle	(2) Cycle Start Year-Day	(3) Altimeter Operating	(4) Applicable MCR	(5) Ku Cal Table Entry, dB	(6) C Cal Table Entry, dB	(7) Poly. Fit Ku Value, dB	(8) Poly. Fit C Value, dB
133	1996-115	NRA	MCR618	+1.05	+0.81	+1.014	+0.853
134	1996-124	NRA	MCR618	+1.05	+0.81	+1.026	+0.866
135	1996-134	NRA	MCR618	+1.08	+0.84	+1.038	+0.878
136	1996-144	NRA	MCR618	+1.08	+0.84	+1.051	+0.891
137	1996-154	NRA	MCR618	+1.08	+0.84	+1.064	+0.904
138	1996-164	SSALT					
139	1996-174	NRA	MCR618	+1.11	+0.90	+1.089	+0.931
140	1996-184	NRA	MCR618	+1.14	+0.93	+1.102	+0.945
141	1996-194	NRA	MCR618	+1.14	+0.93	+1.115	+0.959
142	1996-204	NRA	MCR618	+1.17	+0.96	+1.128	+0.973
143	1996-214	NRA	MCR618	+1.17	+0.99	+1.142	+0.988
144	1996-224	NRA	MCR618	+1.20	+1.02	+1.155	+1.003

Table 3-4 GDR Cal Table for Reprocessing Cycles 133-149 (Continued)

145	1996-234	NRA	MCR618	+1.20	+1.05	+1.169	+1.017
146	1996-243	NRA	MCR618	+1.23	+1.05	+1.182	+1.033
147	1996-253	NRA	MCR618	+1.23	+1.08	+1.196	+1.048
148	1996-263	NRA	MCR618	+1.26	+1.11	+1.210	+1.063
149	1996-273	NRA	MCR618	+1.26	+1.14	+1.224	+1.079

3.3 C-Band Power Drop

Around the time of cycle 140, the TOPEX C-Band Altimeter began to indicate a noticeably more negative slope in the received power per cycle; that is, the rate of power loss began to increase. There are no specific large concerns, but we did notify the Project of this trend; the memorandum addressing this observed C-Band power drop, from David Hancock to John Hultberg, comprises Attachment B of this report. The trend was indicated both in the global average Sigma0 based on the GDR data, and in the Calibration Mode 1 AGC monitoring we perform at Wallops.

We presently use piecewise linear fitting (see Section 3.2) to the global Sigma0 data to provide predicted Sigma0 Calibration Table values for TOPEX production processing for future cycles. For the first couple of years of TOPEX, a single straight line fit provided an adequate representation of the global Sigma0 trend vs. time. More recently, the overall Sigma0 trends in both the Ku- and C-Band altimeters have required the piecewise linear fit which we now use. Prior to cycle 140, the slopes of the linear fits were low, giving us confidence in the predictions, and allowing sufficient time to monitor incoming data for a consistency check with the predicted Calibration Table values.

The change in slope subsequent to cycle 140 indicates the need for C-Band Calibration Table increases of about 0.03 dB on almost every cycle. This raises a concern about the predicted values, and allows less time to verify that the current incoming data are in agreement with the predictions. We were not as much concerned with the slope of the C-Band trend as with the change of that slope. By cycle 150, the trend leveled out from the large slope.

The general feeling is that if characteristics of a system change, one should not extrapolate the data to a decay performance, but should have some concern that the change in characteristics is a precursor to a hard failure at some point in the future. It may limit TOPEX Side A operating life. There is a consensus that switching to TOPEX Altimeter Side B will fix a possible C-Band hard failure.

As a reminder, there are some parts of the TOPEX altimeter that are not redundant, but those are considered to be very reliable. TOPEX has only one Ku- and one C-Band Microwave Transmission Unit (MTU), but each MTU has active components within the chain which are redundant for Side A and B. The other major unit in the receive path is the receiver. Each of the redundant receiver units is shared by the Ku- and the

C-Band systems for its respective side. Within each receiver unit, the input signals feed directly into a power divider (combiner) when they enter the receiver.

A member of the APL reliability group who is knowledgeable about radiation effects on flight hardware (with the caveat that he does not have any quantitative indicators of the TOPEX degradation) believes that radiation damage to electronic parts is less severe for components that are not powered versus components that are powered. Thus, one could expect the TOPEX altimeter Side B to be in better shape than Side A from a radiation damage perspective. So, in general, Side B would be expected to have reliability margin over Side A at this point.

Barton Bull of WFF has completed an investigation into what parts of the C-MTU could affect the receive signal power of the altimeter. He found no components in the receiver that are not common to both Ku- and C-Band except for connectors (see Attachment B). The signals feed directly into a power divider (combiner) when they enter the receiver.

The MTU contains few active components. There are three amplifiers in the signal chain to the receiver. There are no documented radiation concerns associated with these amplifiers.

3.4 Oscillator Drift Algorithm Change

In June 1996, an algorithm error was called to our attention; the error was in TOPEX Algorithm S1034 which corrects altimeter data for oscillator drift. We have confirmed the additive height correction should have been

$$\text{delta height} = [(R_{utc} / R_{ref}) - 1]*H,$$

where H is the uncorrected height estimate, R_{utc} is the measured spacecraft clock interval, and R_{ref} is the nominal spacecraft clock interval. In the current S1034 (used in the original processing of all TOPEX data through cycle 132) however, the expression (R_{utc} / R_{ref}) was erroneously inverted. The R_{utc} and R_{ref} are very close in values (parts in 10^8), therefore the upside down division effectively gives a change in sign to the correction.

This error was found by Ouan-Zan Zanife, Philippe Escudier, and Patrick Vincent, and we are grateful to them for communicating this information directly to Phil Callahan who forwarded it to us. Two important issues can be explained by the error: 1) much of the sea-level change discrepancy between TOPEX and Poseidon should disappear, and 2) the approximately 13 cm bias of TOPEX relative to Poseidon will be removed.

If there were no correction for the oscillator drift made to the TOPEX range estimate, the range after mid 1993 would become shorter with time. The current (about cycle 132) range drift rate induced by the oscillator is about 5 mm per year. The Algorithm S1034 error because of its sign doubles this rate, so that the TOPEX data product range is shorter (or the surface height greater) by about 10 mm per year.

The initial oscillator offset from the frequency used for the range conversion coefficient requires about a 65 mm range correction. This correction was applied with the wrong sign because of the S1034 error. After correcting the TOPEX range for this effect, the TOPEX range will be increased by about 13 cm.

Table 3-5 "Range Corrections for the Effect of Oscillator Drift", located on our Web site at http://osb3.wff.nasa.gov/topex/OscDrift.html gives the range correction, in millimeters, which should be ADDED to the TOPEX range values already processed by JPL to: 1) remove the effects of the S1034 error; and 2) correctly account for the oscillator drift. This correction is directly proportional to the value of the satellite height, and the table's values were produced assuming the height to be 1347 kilometers. (The TOPEX/Poseidon height varies from about 1340 kilometers at the equator to 1354 kilometers at the latitude extreme values.) Again, because of nearly identical values for R_{utc} and R_{ref}, the additive correction for the error is approximately double the value of the true oscillator drift calibration value. Because sea surface height (SSH) reported on the TOPEX GDRs is given by

SSH = Altitude - Range,

the range correction given in the table should be SUBTRACTED from the GDR SSH:

TOPEX GDR SSH corrected for Osc Drift error = GDR_SSH - additive_GDR_range_corr.

The midpoint times in the table are calculated, not actual, but should be good to within about 10 seconds of the actual values.

Users of the Merged GDR, whether PO-DAAC or AVISO, should correct the range before forming the SSH. The correction should be applied to all the originally processed TOPEX data for cycles 1 through 132. Data from cycle 133 onward will be corrected for this effect as well as having revised software for tides and other algorithms as previously announced.

Table 3-5 Range Corrections for the Effect of Oscillator Drift

Cycle	Cycle midpoint date & time	Cycle midpoint J2000 seconds	Additive corr to GDR range, mm
001	1992-272T02:37:21	-229080159	130.60
002	1992-282T00:35:53	-228223447	130.10
003	1992-291T22:34:24	-227366736	129.63
004	1992-301T20:32:56	-226510024	129.16
005	1992-311T18:31:28	-225653312	128.72
006	1992-321T16:29:59	-224796601	128.32
007	1992-331T14:28:31	-223939889	127.95

Table 3-5 Range Corrections for the Effect of Oscillator Drift (Continued)

Cycle	Cycle midpoint date & time	Cycle midpoint J2000 seconds	Additive corr to GDR range, mm
008	1992-341T12:27:02	-223083178	127.59
009	1992-351T10:25:34	-222226466	127.23
010	1992-361T08:24:05	-221369755	126.89
011	1993-005T06:22:37	-220513043	126.59
012	1993-015T04:21:08	-219656332	126.33
013	1993-025T02:19:40	-218799620	126.09
014	1993-035T00:18:11	-217942909	125.85
015	1993-044T22:16:43	-217086197	125.65
016	1993-054T20:15:15	-216229485	125.46
017	1993-064T18:13:46	-215372774	125.31
018	1993-074T16:12:18	-214516062	125.18
019	1993-084T14:10:49	-213659351	125.07
020	1993-094T12:09:21	-212802639	SSALT
021	1993-104T10:07:52	-211945928	124.86
022	1993-114T08:06:24	-211089216	124.76
023	1993-124T06:04:55	-210232505	124.66
024	1993-134T04:03:27	-209375793	124.57
025	1993-144T02:01:58	-208519082	124.48
026	1993-154T00:00:30	-207662370	124.40
027	1993-163T21:59:01	-206805659	124.33
028	1993-173T19:57:33	-205948947	124.29
029	1993-183T17:56:05	-205092235	124.27
030	1993-193T15:54:36	-204235524	124.26
031	1993-203T13:53:08	-203378812	SSALT
032	1993-213T11:51:39	-202522101	124.29
033	1993-223T09:50:11	-201665389	124.33

Table 3-5 Range Corrections for the Effect of Oscillator Drift (Continued)

Cycle	Cycle midpoint date & time	Cycle midpoint J2000 seconds	Additive corr to GDR range, mm
034	1993-233T07:48:42	-200808678	124.37
035	1993-243T05:47:14	-199951966	124.45
036	1993-253T03:45:45	-199095255	124.53
037	1993-263T01:44:17	-198238543	124.62
038	1993-272T23:42:48	-197381832	124.72
039	1993-282T21:41:20	-196525120	124.82
040	1993-292T19:39:51	-195668409	124.94
041	1993-302T17:38:23	-194811697	SSALT
042	1993-312T15:36:55	-193954985	125.18
043	1993-322T13:35:26	-193098274	125.31
044	1993-332T11:33:58	-192241562	125.43
045	1993-342T09:32:29	-191384851	125.56
046	1993-352T07:31:01	-190528139	125.70
047	1993-362T05:29:32	-189671428	125.85
048	1994-007T03:28:04	-188814716	126.01
049	1994-017T01:26:35	-187958005	126.17
050	1994-026T23:25:07	-187101293	126.34
051	1994-036T21:23:38	-186244582	126.52
052	1994-046T19:22:10	-185387870	126.72
053	1994-056T17:20:42	-184531158	126.93
054	1994-066T15:19:13	-183674447	127.15
055	1994-076T13:17:45	-182817735	SSALT
056	1994-086T11:16:16	-181961024	127.60
057	1994-096T09:14:48	-181104312	127.83
058	1994-106T07:13:19	-180247601	128.06
059	1994-116T05:11:51	-179390889	128.30

Table 3-5 Range Corrections for the Effect of Oscillator Drift (Continued)

Cycle	Cycle midpoint date & time	Cycle midpoint J2000 seconds	Additive corr to GDR range, mm
060	1994-126T03:10:22	-178534178	128.53
061	1994-136T01:08:54	-177677466	128.75
062	1994-145T23:07:25	-176820755	128.98
063	1994-155T21:05:57	-175964043	129.21
064	1994-165T19:04:28	-175107332	129.45
065	1994-175T17:03:00	-174250620	SSALT
066	1994-185T15:01:32	-173393908	129.94
067	1994-195T13:00:03	-172537197	130.19
068	1994-205T10:58:35	-171680485	130.46
069	1994-215T08:57:06	-170823774	130.73
070	1994-225T06:55:38	-169967062	131.00
071	1994-235T04:54:09	-169110351	131.27
072	1994-245T02:52:41	-168253639	131.54
073	1994-255T00:51:12	-167396928	131.84
074	1994-264T22:49:44	-166540216	132.20
075	1994-274T20:48:15	-165683505	132.56
076	1994-284T18:46:47	-164826793	132.85
077	1994-294T16:45:18	-163970082	133.12
078	1994-304T14:43:50	-163113370	133.41
079	1994-314T12:42:22	-162256658	SSALT
080	1994-324T10:40:53	-161399947	134.09
081	1994-334T08:39:25	-160543235	134.41
082	1994-344T06:37:56	-159686524	134.68
083	1994-354T04:36:28	-158829812	134.95
084	1994-364T02:34:59	-157973101	135.24
085	1995-009T00:33:31	-157116389	135.59

Table 3-5 Range Corrections for the Effect of Oscillator Drift (Continued)

Cycle	Cycle midpoint date & time	Cycle midpoint J2000 seconds	Additive corr to GDR range, mm
086	1995-018T22:32:02	-156259678	135.96
087	1995-028T20:30:34	-155402966	136.30
088	1995-038T18:29:05	-154546255	136.61
089	1995-048T16:27:37	-153689543	136.91
090	1995-058T14:26:09	-152832831	137.24
091	1995-068T12:24:40	-151976120	SSALT
092	1995-078T10:23:12	-151119408	138.02
093	1995-088T08:21:43	-150262697	138.38
094	1995-098T06:20:15	-149405985	138.70
095	1995-108T04:18:46	-148549274	139.00
096	1995-118T02:17:18	-147692562	139.34
097	1995-128T00:15:49	-146835851	SSALT
098	1995-137T22:14:21	-145979139	140.11
099	1995-147T20:12:52	-145122428	140.45
100	1995-157T18:11:24	-144265716	140.76
101	1995-167T16:09:55	-143409005	141.07
102	1995-177T14:08:27	-142552293	141.40
103	1995-187T12:06:59	-141695581	SSALT
104	1995-197T10:05:30	-140838870	142.16
105	1995-207T08:04:02	-139982158	142.52
106	1995-217T06:02:33	-139125447	142.86
107	1995-227T04:01:05	-138268735	143.21
108	1995-237T01:59:36	-137412024	143.59
109	1995-246T23:58:08	-136555312	144.01
110	1995-256T21:56:39	-135698601	144.42
111	1995-266T19:55:11	-134841889	144.80

Table 3-5 Range Corrections for the Effect of Oscillator Drift (Continued)

Cycle	Cycle midpoint date & time	Cycle midpoint J2000 seconds	Additive corr to GDR range, mm
112	1995-276T17:53:42	-133985178	145.14
113	1995-286T15:52:14	-133128466	145.49
114	1995-296T13:50:45	-132271755	SSALT
115	1995-306T11:49:17	-131415043	146.26
116	1995-316T09:47:49	-130558331	146.66
117	1995-326T07:46:20	-129701620	146.99
118	1995-336T05:44:52	-128844908	147.31
119	1995-346T03:43:23	-127988197	147.63
120	1995-356T01:41:55	-127131485	148.00
121	1995-365T23:40:26	-126274774	148.41
122	1996-010T21:38:58	-125418062	148.80
123	1996-020T19:37:29	-124561351	149.17
124	1996-030T17:36:01	-123704639	149.49
125	1996-040T15:34:32	-122847928	149.84
126	1996-050T13:33:04	-121991216	SSALT
127	1996-060T11:31:36	-121134504	150.68
128	1996-070T09:30:07	-120277793	151.10
129	1996-080T07:28:39	-119421081	151.47
130	1996-090T05:27:10	-118564370	151.82
131	1996-100T03:25:42	-117707658	152.18
132	1996-110T01:24:13	-116850947	152.58

3.5 Seasonal Distribution of Sigma-0 Blooms

In our ongoing assessment of TOPEX Altimeter performance, we have been investigating phenomena we refer to as Sigma-0 blooms. A Sigma-0 bloom is characterized by abnormally high Sigma-0 values. Our initial investigations revealed a direct correlation between the occurrence of blooms and low significant waveheights. This has led us to theorize that the blooms are the result of very strong radar returns from smooth ocean surfaces during periods of calm winds.

Using our WFF TOPEX GDR Database, we are able to determine the global distribution of these blooms. We use a criteria of over-ocean Ku-Band Sigma-0 greater than 16 dB to identify blooms from the 1-minute average GDR Database.

The seasonal geographic distribution of blooms for the year 1996 are shown in Figure 3-9 "Seasonal Distribution of Blooms During January-March 1996 and April-June 1996" on page 3-33 (upper and lower) and in Figure 3-10 "Seasonal Distribution of Blooms During July-September 1996 and October-December 1996" on page 3-34 (upper and lower), respectively. The occurrences of the blooms within discrete geographic areas are observed to be seasonal, as the presence of calm seas is seasonal. Accordingly, the majority of the blooms in the Northern Hemisphere occur during its spring and summer months (April-September), and the majority of the Southern Hemisphere blooms occur during its spring and summer months (October-March). The blooms clustered near the southernmost latitudes near Antarctica are believed to be the result of sea ice rather than calm seas.

The year-to-year patterns of distribution are very similar except that there are more sea-ice-induced blooms in 1993 and 1994 than in the later two years. The number of Sigma-0 blooms per year have been:

Year	Blooms
1993	5,126
1994	5,321
1995	4,285
1996	4,326

Global seasonal movement of Sigma-0 blooms may be viewed by downloading a WFF-produced QuickTime movie (196k) of monthly Sigma-0 blooms from data observed by TOPEX from January 1993 to October 1995. This QuickTime movie may be accessed at http://osb3/topex/blooms/.

3.6 Effects of Coastlines

As part of our ongoing TOPEX performance assessment program, we have examined the effects of nearby land (continental coastlines and islands) on the TOPEX altimeter's measurements. In the course of our analysis, we have studied offshore altimeter measurements in close proximity to a variety of terrain including mountains, lowlands, hills and islands.

Guidelines for data users to assess the data quality, when using TOPEX altimeter measurements in close proximity to land, have been developed and are discussed in Brooks, *et al* (1996). Techniques are also presented in that document such that the data user may rectify some of the affected data, and recover the sea surface topography. The results of the study were presented at the Pacific Ocean Remote Sensing Conference in Victoria, British Columbia, in August 1996. The Brooks, *et al* (1996) paper will be published in the Conference Proceedings, expected to be available in 1997.

The presence of land affects the altimeter's measurements. The nature of the effects, and the distance from the shoreline at which the measurements are affected, vary

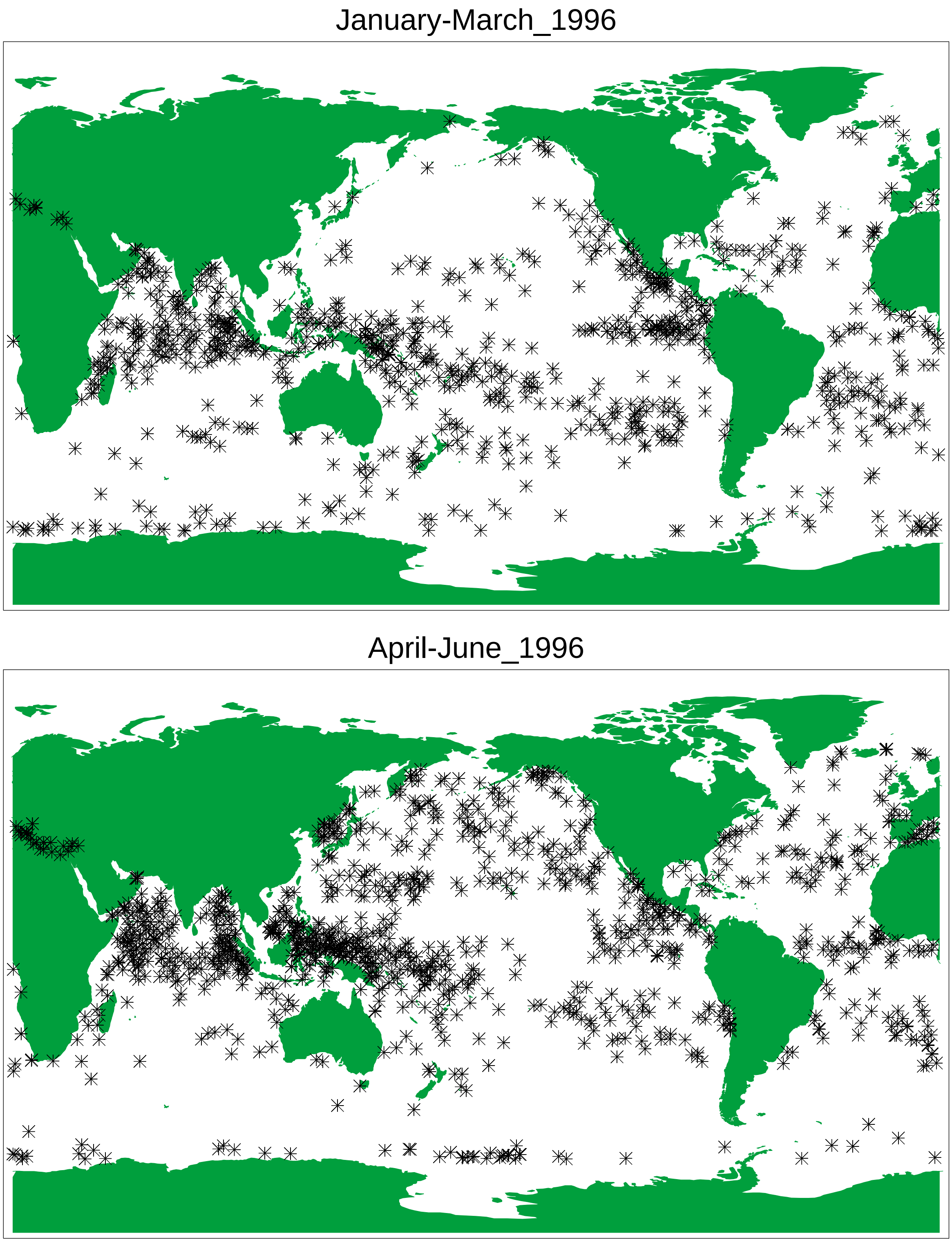
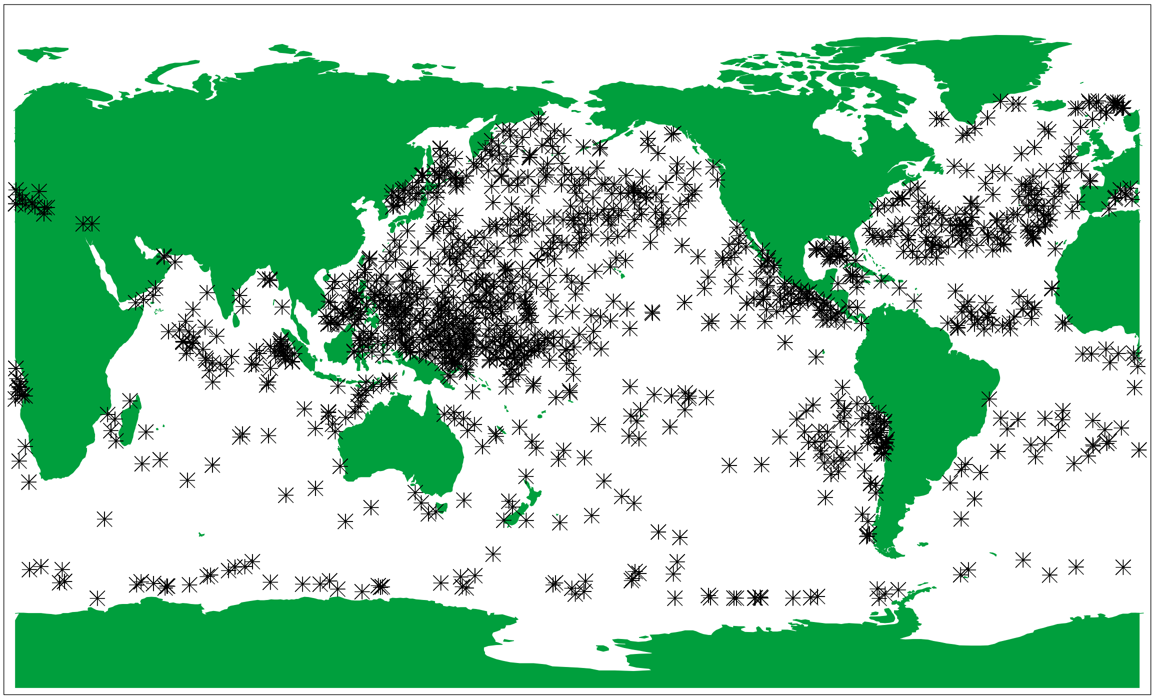


Figure 3-9 Seasonal Distribution of Blooms During January-March 1996 and April-June 1996

July-September_1996



October-December_1996

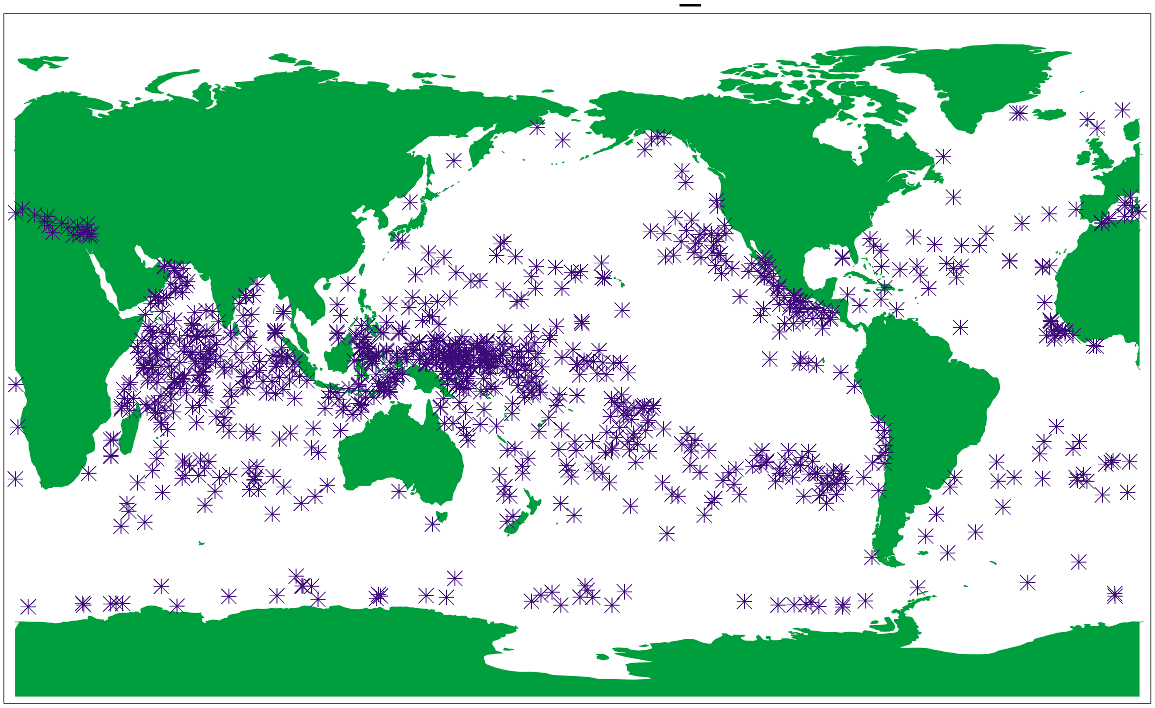


Figure 3-10 Seasonal Distribution of Blooms During July-September 1996 and October-December 1996

with both the type of terrain along the shoreline and whether the altimeter is approaching or going away from the shoreline. This study indicates that the altimeter-derived sea surface topography for a groundtrack, as supplied in GDR files, may be extended several kilometers shoreward by the use of retracking and data corrections. In the case of subdued shoreline topography, such as southern Borneo, the sea surface topography may be extended nearly to the shoreline.

For near-coastal studies, the user of the TOPEX GDR data should monitor bit 2 of the Alt_Bad1 flag. When this bit is set, it indicates that the altimeter waveforms are misshaped or misaligned, and will require retracking.

3.6.1 Water-to-Land

For land effects while approaching a shoreline, Table 3-6 "Approaching a Shoreline" on page 3-36 summarizes our analyses of the full-rate waveforms for nine test cases scattered around the Pacific Rim. The leftmost column of Table 3-6 identifies the particular study area, and the latitude/longitude of the groundtrack's crossing of the shoreline. The next column provides the TOPEX cycle and pass number which was used in this analysis; the pass groundtracks repeat within $\pm$1 km crosstrack every 9.92 days. The third column generally describes the nature of the terrain along the shoreline in this area. The fourth column from the left provides the maximum distance from the nearest land that land reflections are discerned in this area's waveforms, based on a personal inspection of the full-rate waveforms. Land reflections appeared as early as 10.8 km from land (near the edge of the 11.0 km footprint) for the Japan study area, and as late as 5.6 km for Yangma Dao, China.

The next column is the maximum distance from the shoreline at which bit 2 of the Alt_Bad1 flag is set. This distance is equal to or greater than the distance that land returns appear in the individual waveforms, as this flag is set for an entire frame even though not all of the waveforms in the frame may have been affected. This distance from land will vary from cycle-to-cycle because the inter-cycle frame boundaries are not geographically aligned.

The sixth column from the left lists the distances from land for which the high-rate waveforms could be retracked to recover the sea surface topography.

The seventh column provides the distances from the shoreline for which the sea surface heights are not recoverable by retracking. This is the result of the land returns occurring in the early gates of the waveforms, prior to the sea surface returns. For these water-to-land transitions, the ocean surface topography is recoverable all the way to the shoreline only for the three subdued topography areas of 1) southern Borneo, 2) Isle de Santa Margarita off the coast of Baja California, and 3) Yangma Dao island off the coast of China's Shandong Province. Based on this study, the sea surface topography is recoverable to a distance of about two kilometers from a shoreline. The selected threshold for each area's retracking in shown in the last column.

3.6.2 Land-to-Water

For altimeter groundtracks receding from land, the results are tabulated in Table 3-7 "Receding from a Shoreline" on page 3-37. The column descriptions are the same as

Table 3-6 Approaching a Shoreline

Study Area and Latitude/Longitude of Water-to-Land Transition	TOPEX Altimeter Cycle/Pass	Type of Shoreline Terrain	Max. Distance Land Appears in Ocean Waveform (km)	Max. Distance Alt_Bad1 Flag is Set (km)	Waveform Retracking and Correction Needed (km)	Data Not Recoverable Distance from Shoreline (km)	Threshold for Retracking (counts)
Borneo (southern) 2.9°S,110.2°E	Cycle 135 Pass 051	Low, swampy	9.6	9.6	0 - 9.6	none	2000
Honshu, Japan 36.5°N,136.5°E	Cycle 099 Pass 010	Hilly	10.8	15.7	5.4 - 15.7	0 - 5.4	2500
South Island, New Zealand 41.6°S,171.9°E	Cycle 075 Pass 010	Mountain-ous	6.7	7.5	2.3 - 7.5	0 - 2.3	2000
Vancouver Island, British Columbia, Canada 49.2°N,234.0°E	Cycle 137 Pass 095	Rugged Islands	6.4	11.6	2.3 - 11.6	0 - 2.3	1500
Isle de Santa Margarita, Baja California, Mex-ico 24.3°N,248.3°E	Cycle 137 Pass 169	Low-lying	7.0	8.1	0 - 8.1	none	1500
Sonora, Mexico 27.2°N,249.6°E	Cycle 137 Pass 169	Marshy	7.5	12.8	1.2 - 12.8	0 - 1.2	1500
Chile (central) 38.8°S,286.6°E	Cycle 137 Pass 139	Rugged	8.2	9.8	2.5 - 9.8	0 - 2.5	500
Kamchatka Pen-insula, Russia 56.2°N,155.8°E	Cycle 137 Pass 058	Marshy	10.4	10.4	3.4 - 10.4	0 - 3.4	1000
Yangma Dao (Island), Shandong Prov-ince, China 37.5°N,121.6°E	Cycle 137 Pass 138	Low-lying	5.6	12.2	0 - 12.2	none	1500

for Table 3-6. In column four of Table 3-7, the maximum distance at which land reflections appear in the waveforms are about the same as in Table 3-6, except for the areas of Baja California, Magadan, Russia, and China's Liaoning Province, for which there were no land reflections. In these three areas, the altimeter did not lock-up on the sea surface until the groundtrack was beyond the distance at which the land reflections would have appeared. These three areas nonetheless will benefit from waveform retracking due to the altimeter tracker's requiring about a second of time (ten waveforms) to settle-out after reacquiring the sea surface. The Alt_Bad1 flag is set in these three areas due to the waveforms not being stabilized with respect to the tracking gate during the settling-out period. In none of these nine areas was the sea surface recoverable all the way to the shoreline.

Table 3-7 Receding from a Shoreline

Study Area and Latitude/Longitude of Water-to-Land Transition	TOPEX Altimeter Cycle/Pass	Type of Shoreline Terrain	Max. Distance Land Appears in Ocean Waveform (km)	Max. Distance Alt_Bad1 Flag is Set (km)	Waveform Retracking and Correction Needed (km)	Data Not Recoverable Distance from Shoreline (km)	Threshold for Retracking (counts)
Borneo (southern) 3.1S°,110.9°E	Cycle 135 Pass 140	Low, swampy	5.6	13.4	6.1 - 13.4	0 - 6.1	1000
Honshu, Japan 34.7°N,137.6°E	Cycle 099 Pass 010	Mixed Terrain	7.1	12.1	5.8 - 12.1	0 - 5.8	1000
South Island, New Zealand 43.1°S,173.0°E	Cycle 075 Pass 010	Mountain-ous	8.8	9.3	6.3 - 9.3	0 - 6.3	2000
Vladivostok, Russia 43.0°N,131.8°E	Cycle 099 Pass 010	Mixed Terrain	5.9	12.2	1.9 - 12.2	0 - 1.9	1500
Baja California, Mexico 25.6°N,248.8°E	Cycle 137 Pass 169	Mountain-ous	n/a	15.7	10.4 - 15.7	0 - 10.4	1500
Magadan,Russia 59.5°N,149.0°E	Cycle 137 Pass 058	Rugged	n/a	15.7	10.2 - 15.7	0 - 10.2	2000
Kamchatka Pen-insula, Russia 53.7°S,159.8°E	Cycle 137 Pass 058	Mountain-ous	7.5	7.5	5.8 - 7.5	0 - 5.8	1000
Liaoning Prov-ince, China 40.0°N,119.9°E	Cycle 137 Pass 138	Low-lying	n/a	34.8	20.5 - 34.8	0 - 20.5	1500
Shandong Prov-ince, China 36.9°N,122.0°E	Cycle 137 Pass 138	Low-lying	4.1	14.5	2.8 - 14.5	0 - 2.8	500

3.6.3 Plans for Further Land Effects Studies

We are pursuing further studies of rectifying the land-affected measurements from TOPEX. The short-term goal is to develop, test, and demonstrate an automated technique for recovering, to the extent possible, sea surface heights in the vicinity of coastlines. That technique would then be made available to TOPEX data users who wish to extend shoreward the altimeter-derived sea surface topography.

Section 4

Engineering Assessment Synopsis

4.1 Performance Overview

After nearly four-and-a-half years of on-orbit operations, the NASA Radar Altimeter on the TOPEX/POSEIDON spacecraft remains healthy and its performance meets or is better than all pre-launch requirements. The performance requirements are listed in Section 4.0 of the February 1994 Engineering Assessment Report.

The primary pre-launch specification for the altimeter is to monitor and maintain range calibration to the $\pm$1.5 cm level. We are well aware that TOPEX science investigators are achieving extraordinary results with this altimeter data set, and are seeking unprecedented range measurement accuracy. With our improved analysis techniques, we believe that we are achieving range calibration (i.e., internal range consistency) at the one-centimeter level, and are making strides towards the sub-centimeter level.

A recommendation we have is for the Project to consider operating Side B for about 5% of the cycles. This would give us insight to Side B performance and the characteristics of the stored parts. More importantly, it would provide some data points to be used to help cross-calibrate Side B relative to Side A, calibration data that would be very important to have if there were to be a failure on Side A. The commands to switch from Altimeter Side A to Altimeter Side B would, among a number of other things, switch receiver units and would switch to the different internal chains within the single C-Band MTU. At least one of the switch functions has been operated (toggled) each time the Altimeter has been switched off by the spacecraft as part of the Altimeter turn on procedure. However, it is proper to remind ourselves that Side B has never been powered-on in space.

We are continuing our NASA Radar Altimeter performance assessment on a daily basis, and are continuing to develop improved analysis techniques. Our performance assessment techniques are relevant not only for the NASA Radar Altimeter, but should be very applicable to other altimeters, as well.

Section 5
References

5.1 Supporting Documentation

R.L. Brooks, D.W. Lockwood, J.E. Lee, D.W. Hancock III, and G.S. Hayne, 1996, Land Effects on TOPEX Radar Altimeter Measurements in Pacific Rim Coastal Zones. Presented at Pacific Ocean Remote Sensing Conference, Victoria, British Columbia.

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D.W. Hancock III, R.L. Brooks, and J.E. Lee, 1995, Passive Microwave Radiation Effects on the TOPEX Altimeter Cal-2 Measurements. TOPEX / POSEIDON Research News, August 1995, pp. 4-8.

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G.S. Hayne, D.W. Hancock III, and C.L. Purdy, 1994, TOPEX Altimeter Range Stability Estimates from Calibration Mode Data. TOPEX / POSEIDON Research News, JPL 410-42, Issue 3, pp.18-22.

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Section 6

Attachment A

To: John Hultberg

From: David Hancock

Subject: TOPEX Altimeter 1996d362t 12:55 Side B C MTU Transmit Anomaly

Date: 12/27/96

An anomaly occurred with the TOPEX altimeter on 1996 day 362 about 12:55:21 UTC. The anomaly was that the C MTU Transmit side switched from side A to side B. The altimeter was successfully returned to track on day 362 about 17:45. All data indicates the altimeter is performing normally and no harm was done to any components.

The problem occurred during realtime pass d362t12:28. The altimeter engineering bilevel one bit for the C MTU Transmit side changed to indicate side B. This is an alarmed monitor and was reported as an alarm condition. It appears that C MTU Transmit section was switched to side B. The C band signal was mostly lost with the system trying to track a signal at about 13 db AGC. The return waveform appears to be a combination of noise and a real return from some leakage of the C band TX through switch. Over ice a higher level signal was received that was tracked.

The problem was very similar to an event that happened 1995 d157t201600, where the Ku MTU receive side switched from side A to side B. We determined during the 1995 recovery that the toggle of the MTU A/B switch fixed the problem and that a ground reset does not fix the problem. Also we recommended that a future sequence to recover from similar events would be an SA05, SA06, and SA08.

On realtime pass d362t1727 the approved command request A00012 containing the SA05, SA06 and SA08 command sequence was executed. The SA05 and SA06 was executed to bring the altimeter to normal idle. The commanded SA08 transitions from idle to track with performing a calibrate mode sequence. SA08 contains a toggle of the A/B MTU switch. This toggle fixed the problem. All commands appeared to perform normally and all data appeared valid. Post-pass analysis of the data indicates proper performance of the altimeter after the toggle back to side A.

The switch to C MTU transmit side B was real. This most likely was caused by some upset of the synchronizer. The side A/B control is taken from the ICA command word and the telemetry indicator is not an actual reading of a hardware switch. There was no indication in the telemetry of the altimeter having received any commands that would have caused the switch. The ICA A/B switch command causes the synchronizer to generate four MTU control signals to change state for side selection: Ku transmit, Ku receive, C transmit, and C receive. There is no method an ICA command could have caused the state C transmit to be side B and the Ku transmit, Ku receive, and C receive states all to remain at side A. However since the telemetry shows the change and the altimeter performance indicates that a real switch occurred, the MTU change must have been commanded from the altimeter electronics box. This is an error within the altimeter, and is not attributable in any way to an altimeter commanding error. During this period the Ku Band altimeter performed normally and its data are good.

I commend the TOPEX team for outstanding support in all areas. The problem detection, command generation, command approval, command execution, data analysis, and data availability were excellent. I believe this again shows why TOPEX is always a first class project.

We must now monitor this for any repeat occurrence. The present alarm system does monitor this properly. The proper recovery we now know to be a normal return to idle (the TWTA and CSSA do not have to be turned off) and normal sequence to return to track. The sequence is SA05, SA06, and SA08.

Please contact me if you have any additional questions.

David Hancock

cc: Craig Purdy
George Hayne
Larry Rossi
Ron Brooks
Sheldon Rosell / JPL
Paul Marth / APL

Section 7

Attachment B

To: Jet Propulsion Laboratory
Attn.: Spacecraft Systems Engineering Section
John Hultberg / 264-355

From: David Hancock

Subject: TOPEX C Band Received Power Study Results

The characteristics of the C-band received power have been closely examined over the past few months related to the apparent rapid rate of change noted in October 1996. The concerns are now much less about what had seemed at that time to be a significant characteristic change.

It became clear in December, with additional data, that in October the rate of change had been overestimated. There was a change in the trended rate but not as large as raised the initial concern.

Barton Bull at WFF has completed an investigation into what parts in the C-MTU could possibly affect the receive signal power of the TOPEX Altimeter. He found no components in the receiver that are not common to C- and Ku-band except connectors. The signals feed directly into a power divider (combiner) when they enter the receiver (PD1 on 7301-5001). Therefore, any changes would be seen at the C-band MTU output to the receiver (J8 on 7301-0301).

The MTU contains few active components. In the signal chain to the receiver, Barton identified three amplifiers and obtained their specification sheets. The amplifiers are:

A3 contains an active component WJ-A76-S,
manufacturer code 14482 by Watkins Johnson.

AR1 (PI10786-1) is an AMF5056 from APL lot number X811-0,
manufacturer - MITEQ.

AR3 (PI10786-2) is an AMF-4650-27684 from APL lot number X826-0,
manufacturer - MITEQ.

Barton has provided me a package with the spec sheets, the drawings cited, and some other materials. There is no material that specifically addresses the radiation susceptibility of the parts, and the manufacturers' representatives interviewed could provide nothing pertinent. Barton did verify that none of the amplifiers appeared on the lists, prepared by Dick Maurer of APL, which documented radiation concerns as the TOPEX project development progressed.

Based on the current trends and the study by Barton, I recommend that we close the open concern on the received C-band power. I will file the information that Barton has provided me. The next step, if the issue comes back, would be to provide the data package to quality assurance for a deeper investigation of the most likely component and to formulate predicted failure modes.

David Hancock
Observational Science Branch

cc:
822.2 / Mr. Craig Purdy
972.0 / Dr. George Hayne
972.0 / Mr. L. Larry Rossi
972 / CSC / Mr. Ron Brooks
JPL / Dr. Sheldon Rosell
APL / Dr. Paul Marth